SOME ASPECTS OF LOGICAL THINKING WITHIN PIAGETIAN CONTEXT AMONG CERTAIN GROUPS OF AVERAGE ADOLESCENT GIRLS

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CERTIFICATE

This is to certify that Mrs. Sadhana Joshi, student of this college has conducted and completed the present dissertation entitled "SOME ASPECTS OF LOGICAL THINKING WITHIN PIAGETIAN CONTEXT AMONG CERTAIN GROUPS OF AVERAGE ADOLESCENT GIRLS" under my guidance and supervision.

Her work is genuine and original.

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CONTENTS

Pages

CHAPTER I SOME BACKGROUND ISSUES UNDERLYING THE PROBLEM 1 - 18

Introduction 1

Definitions of the Problem 2

Thinking 3

Problem Solving 5

Problem Solving Behaviour 7

The Geneva School 8

Piagetian Theory 9

Stages of Intellectual Development 11

The Sensory Motor Stage 12

The Pre-operational Stage 13

The Concrete Operational Stage 14

The Formal Operational Stage 15

Why This Study? 17

CHAPTER II REVIEW OF RELATED LITERATURE 19 - 35

Introduction 19

Studies on Problem-Solving Method 20

Studies on Relationship of Intelligence with Problem Solving and Intellectual Level of Development 24

Studies Related to the Relationship of the Intellectual Development with Problem-solving 26

Studies Related with Stages of Development using Written Piagetian Task 29

Studies on Stages of Development 31

Pages

CHAPTER III THE PRESENT STUDY 36 - 62

Introduction 36
The Research Design 37
Aims and Objectives 37
Hypotheses to be Tested 37
Method of Procedure 38
Criteria for Selection of the Institution and Sample 38
Sample and Subject 39
Tools used 40
Intelligence Test 41
Description of Intelligence Test 41
Reliability and Validity of the Test 42
Administration and Scoring 43
Written Piagetian Type Tasks 43
Definition of Schemes of Thought 45
The Individual Description of Problems
Administration of Questionnaire 61
Delimitations 61

CHAPTER IV ERRORS COMMITTED DURING PROBLEM SOLVING AND THE ACQUISITION OF PROBLEM SOLVING PROCESSES 63 - 81

SECTION A Introduction 63
Past Literature 66
The Present Study 67
Incidence of Content 70
Interpretation of Table IV 74

SECTION B Acquisition of Problem-Solving 76
Interpretation of Table V 80

Pages

CHAPTER V STATISTICAL ANALYSIS AND INTERPRETATION OF THE DATA 82 - 93

Introduction 82
Interpretation of Table VI 84
Interpretation of Table VII 85
Interpretation of Table VIII 86
Interpretation of Table IX 87
Interpretation of Table X 88
Interpretation of Table XI 89
Interpretation of Table XII 90
Interpretation of Table XIII 91
Interpretation of Table XIV 92
Conclusion 93

CHAPTER VI FACTOR ANALYSIS AND INTERPRETATION OF FACTORS 94 - 104

Introduction 94
Some Related Studies 94
The Present Study 97
Correlation Matrix 97
Obtaining the Factors 99
Interpretation of the Factors 100
Conclusion 104

CHAPTER VII SUMMARY, EDUCATIONAL IMPLICATIONS AND SUGGESTIONS 105 - 116

Introduction 105
Past Work 106
Problem Restated 108
Aims and Objectives of the Study 108

Pages

Hypotheses to be Tested 109
Method of Procedure 109
Sample and Subject 109
Tools Used 110
Statistical Analysis 111
Delimitations 111
Main Findings 111
Educational Implications 113
Suggestions for Further Research 115

BIBLIOGRAPHY 117 - 122

APPENDICES
I Written Piagetian Type Tasks (Section I)
II Written Piagetian Type Tasks (Section II)
III Battery of Twelve Piagetian Tasks in English Language
IV Original Data of Different Variables

LIST OF TABLES

Table No.		Page
I	Coefficients of Reliability and Validity of the Test of Piaget Type Tasks	44
II	Schemes of Thought, Contact Problems as well as Process, Number of Processes and the Maximum Score Possible on the various Schemes of Thought	46
III	Dominant Error and its Gradewise Distribution in Percentages on Schemes of Thought : Proportion, Classification, Cons.of Vol., Probability, Testing Hypotheses and G.S.P.	68
IV	Errors Committed, Number of Errors Committed and Gradewise Distribution of Incidence of Content Influence in Percentages on Processes of Problem 1 to 12	71
V	Sum Total Acquisition of Forty Two Processes of Thought Derived from the Twelve Problems in the Descending Order of Percentages, Gradewise	77
VI	Gradewise, Mean and S.D. of Each Scheme of Thought	83
VII	Showing Mean, S.D. and t-values of Using Constant Difference between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X, X & XI	85
VIII	Showing Mean, S.D. and t-values of Scheme of Proportion Between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI	86

Table No.		Page
IX	Showing Mean, S.D. and t-values of Scheme of Classification between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI	87
X	Showing Mean, S.D. and t-values of Conservation of Volume between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI	88
XI	Showing Mean, S.D. and t-values of Scheme of Probability between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X, X & XI	89
XII	Showing Mean, S.D. and t-values of Testing Hypotheses between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI	90
XIII	Showing Mean, S.D. and t-values of Grasping the Essence of the Problem Between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI	91
XIV	Showing Mean, S.D. and t-values of Stating Procedure between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI	92
XV	Correlation Coefficients for Variable No.1 to 10	98
XVI	Varimax Rotated Factor Matrix for Variable 1 to 10	100
XVII	Eigen Values, Percent of Variance and Cumulative Percentage for the Two Factors	102
XVIII	Showing Name of the Problem and Schemes of Thought	110

LIST OF GRAPHS

Graph No.

1 Hump of the Dominant Error on Problem & Process No. 2(6) of Scheme of Proportion.

2 Hump of the Dominant Error on Problem & Process No. 3(10) of Scheme of Classification.

3. Hump of the Dominant Error of Problem & Process No. 4(15) of Conservation of Volume.

4. Hump of the Dominant Error of Problem & Process No. 10(34) of Scheme of Probability.

5. Hump of Dominant Error of Problem & Process No. 11(37) of Testing Hypotheses.

6. Hump of Dominant Error of Problem & Process No. 12 (38) of Grasping the Essence of the Problem.

LIST OF FIGURES

Figure No.		Pages
1.	Significant Loadings of Varimax Factor I	102
2.	Significant Loadings of Varimax Factor II	103

CHAPTER I

SOME BACKGROUND ISSUES UNDERLYING THE PROBLEM

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Introduction

A problem arises when activity is blocked by an 'obstacle' between the problem solver and his goal, and that cannot be removed by use of ready-made habits. The obstacle can be something present that must be changed or something absent that must be found or sometimes all the necessary factors are present, but a person has to learn to see them differently. To remove obstacle, problem solver is bound to think. Some obstacle may be removed purely by thinking. Some require a combination of thought, experiment and observation. Even those solved by thought alone are usually checked against experience.

A problem can be solved only when the obstacle between the problem solver and the goal is within his capacity to remove. Because of differences in perception, knowledge and in skills, no two people face quite the same

problem in the same problematic situation. An individual's ability to identify a problem depends not only on general intelligence, but also on his previous knowledge.

Definitions of the Problem

A problem starts with puzzlement, when the observer is confronted with a discrepant factor and asks why? A problem is essentially the recognition of a solution that is not satisfied by previous knowledge.

A problem is a pattern of events that is recognized as different from that which was expected by the learner, and which leads to anticipation that a desirable outcome will be blocked or that an undesirable outcome has become more probable (M.Daniel Smith, 1971).

We speak of a 'problem' when its solution is either by logic or by insight (Munn).

According to Brownell a problem is found somewhere intermediate in a continum having puzzle type at one end and familiarity and complete understanding at the other end.

Problem
Puzzle ———————— Complete understanding

In order to deal successfully with a problematic situation, the person involved must be able to structure the situation sufficiently with a view to identify the problem. He must be able to analyse the situation to see what elements are relevant to the solution of the problem

and equally important, what elements are not. If he can do this, he can launch an attack on the problem. Problem solving in science fosters individual thinking. A good thinker in one situation should be capable of thinking in other situations or areas also. The problem solving strategies are the basis to discovery of the solutions of new problems. Further, it has been observed that the student's gained insight into science by solving theoretical problems other than by reading all the answers in a text book.

Thinking

Solving Problems involves "creative thinking". Productive problem solving begins when the thinker realizes the problem i.e. when he sees the inner structure of the situation. The structural strains produce tensions in the thinker's mind, and vectors are set up determining the step to be taken to transpose the incomplete situation into one that is structurally complete.

Sometimes we find people are unable to express their ideas and views to another, but a kinesthetic thinker can explain his conception to another person in better manner than a man who does not think well.

To encourage originality in our students classroom activity should be based on scientific method. A teacher should ask thought-provoking questions to stimulate

productive thinking among students. ....Problem-solving requires those internal events usually called thinking.... (Deccelo, 1970). In literature, the term thinking refer to 'abstracting, analysing, comparing, deducing, defining, discriminating, estimating, generalising, guessing, imaginning, judging, knowing, opining, reasoning, recalling, recognising, reflecting, remembering, searching for conclusions and understanding'.

Hearenshaw's view regarding thinking is quite consistent with Piaget's genetic findings. According to him thinking is a 'ghost like' activity for it has to be inferred rather than observed. Thinking should be regarded as a skill (or group of skills). With the passage of time, this skill becomes quite complex and is characterised by 'flexibility, transfer, generalization and accurate discrimination processes'. Which ultimately result in the development of highly abstract conceptual systems, conceptual systems of high order and generality.

Maltzman on the basis of his formulation distinguishes thinking between reproductive and productive thinking, whereas Guilford (1959) explains two methods of thinking i.e. divergent and convergent thinking. Peel mentions and distinguishes among four kinds of thinking these are (i) Thematic thinking, (ii) Explanatory thinking, (iii) Productive thinking, (iv) Integrative thinking .

The above mentioned views show that the problem-solving is one of the most important aspect of human thinking.

Problem Solving

The problem-solving approach in science is a technique which promotes learning through confronting students with a distinct problem which requires a solution. Problem solving is the solution of a distinct, stated problem as contrasted to generalities, irrelevancies, and acquisition of knowledge that serves no immediate purpose. To quote Stollberg (1956).

> "Problem-solving is not a series of fixed steps described in science texts from three to four or up to ten steps in number... it is an assortment, not a pattern of skills, attitudes, and habits... the individual who has a reasonable command of certain well selected facts, important principles and broad generalizations related to his problem can arrive at a better conclusion and do it quicker than a person who is not familiar with the general field of difficulty".

Problem-solving is not a panacea. It is no cure-all for the ills of science instruction and science education; problem-solving does not train the unintelligent to make wholly intelligent decisions nor does it assist the scientifically immature to postulate or conclude maturely. Rather it is the placement of content into

action, its success being keyed to knowledge. Problem solving is a method. The desired outcomes are curious minds, alert to situations that are incongruous with what is currently known to them, possessed of zest for seeking out expectations and truths, having a knowledge of investigation through some determined plan of attack, working toward a solution, and then being courageous enough to react to conclusion. In the words of Professor Vaidya (1968).

> "Problem-solving takes place as soon as the problem is perceived by the problem solver and is aimed at to reach the goal stated by the problem. The problem is supposed to be not only new and novel but also at the same time, there is supposed no direct solution available to the problem solver at the time of its presentation. Moreover, it is also assumed that the problem solver possesses the basic information needed to solve the problem".

Definition of problem solving differs from the "Simple findings of exceptions" (Hazlitt) to "formal reasoning of a complex nature",(Piaget). Maier treats problem solving as "combining the essentials of two isolated experiences". Welch takes it as "the integrated activity of perceptions, memory, recall, association, generalization and reconstruction of ideas".

Problem solving is closely related to principle learning in which lower-order principles are applied in

the learning of higher order principles. In this view, successful problem solving results in the acquisition of new knowledge just as does the successful learning of concepts and principles (Gagne, 1964).

Problem-Solving Behaviour

Problem-solving is behaviour reinforced by the restoration of the familiar or anticipated pattern of events, assumedly through decrease in anxiety over the possible frustration of expectations, or over the possible occurence of the aversive outcome. Thus problem solving behaviour is reinforced by a desirable change in the problem situation. A problem as a result, is a "motivating" situation. Motivation is based to some extent on the perception of a problem by the learner.

J.Stanley Gray regards problem solving behaviour of course, a process, but also adjustment with difficulties and interferences encountered in a problem situation. It is a way of proceeding in spite of interferences.

The most extensive work on the Problem-solving processes of children has been done by Piaget. He has studied the developmental aspect of human thinking and development of reasoning starting from birth till late adolescence. Piaget says, A child differs from an adult in many ways. This is obvious not only in physical appearence but in social interaction, responsibility,

capability of self-direction, work habits, etc. Yet many teachers often interact with their pupils as though they were mentally like adults. The teacher who thinks logically i.e. deductively, often assumes that his students can easily follow and perform this type of reasoning also. Research done by Professor Jean Piaget and his colleagues indicates that this often is far from the truth for a large segment of the elementary school population. Children do not act like adults nor do they think like them. In fact, it is the function of the schools to help children develop their abilities through their educational years.

The Geneva School

In recent years, the Swiss Psychologist Jean Piaget and other developmental psychologists at the International Centre for Genetic Epistemology in the Jean Jacques Rousseau, Institute (Geneva) Switzerland have enjoyed a new and increased interest in United States. Perhaps Piaget's most notable and significant contribution to contemporary educational thought and practice has been his characterization of specific intellectual developmental stages of children. Piaget's approach is both theoretical and experimental. His work is based on extensive observation of individual children. The subject matter of his investigation ranges from the intellectual to the morale sphere.

Piagetian Theory

The theories of Piaget have been well received by many educators and psychologists. He has become the most popular and most cited authority in the educational literature, particularly in the field of growth of logical thinking from the childhood to the late adolescence. Jean Piaget (1896-1980) is one of the most outstanding person contributing to psychology and education in the 20th century.

During 50 years of studies, he and his co-workers in Geneva have observed and examined thousands of subjects, ranging in age from the newborn to the adolescent. Some 30 volumes and countless articles on the subject of infant and child thought have been published, his work represents a major contribution to our understanding of the development of human thought. Piaget's theory of intelligence is unique in its complexity and comprehensiveness.

Piaget began his ingenious study of child development with the careful observation of his own three children. From this beginning, his investigations were gradually extended to other children and have resulted in the publication of a vast number of research papers, monographs and books.

Piaget's concern with theory can also be seen in his interviewing methods. He has described his method as

a "Clinical method" - very similar to the procedures of Psychiatric examination. The interview with the child must be flexible. The investigator, drawing upon theory, must be ready to very the form of his questions and tasks depending upon the response of the subject. The good interviewer, says Piaget, must combine two seemingly incompatible qualities. On the one hand, "he must know how to observe, that is to say, to let the child talk freely, without ever checking or side-tracking his utterance". And on the other hand, the interviewer "must constantly be alert for something definitive, at every moment he must have some working hypothesis, some theory, true or false, which he is seeking to check". He notes the child's verbal reacion to the problem and the child's justification of his solution.

Piaget did not think of himself purely as a child psychologist, but rather as a "genetic epistemologist". A genetic study of the child is one that higher processes of concept formation are seen to evolve from biological mechanism which are rooted in the development of an individual's nervous system. The Epistemology is concerned with the theory of knowledge. Piagetian theory has two important central ideas :

(1) Children's intellectual capacity passes through a number of quality contrasting stages before adulthood.

(ii) A child's interaction with his environment plays a very significant role in his transition from one stage to the next stage (Karplus et.al, 1967).

Piaget's theory has been more concerned with understanding, rather than controlling behaviour. Intelligence is viewed as a process of organization and adaptation. When a child encounters an object, he will attempt to organise the object into his present schema or structure. When schema are present, assimilation will occur. If the assimilation does not take place, the child is at disequilibrium until present schemes are altered or new ones developed. A group of schema that occur more or less at the same time make up a "Stage" in Piaget's model of child development.

Stages of Intellectual Development

According to Piaget, children develop intellectually in a sequence of stages by age from infancy to post-adolescence. A baby clearly comes into the world with an unfinished mind, and, as he grows and matures, he slowly evolves through the year into a mature adult capable of performing fantastic mental, computer like operations. Each stage of learning is necessary for the development of the stages that follow. A child cannot skip a stage because each stage not only utilizes and integrates the preceding stage but paves the way for the one that follows. Although the sequence of stages is the same for all children, the

rate at which particular children pass through these stages will depend upon both the children's heredity and their socio-economic environment. There are four major stages in Piaget's theory.

THE SENSORY - MOTOR STAGE (0-2 years)

A Period of Discriminating and Labelling

The sensory motor stage is described as stimulus bound because the child mainly interacts to stimuli from without. This stage is completed before the development of speech i.e. language has not yet appeared, and the child can only perform motor actions. These actions have some of the features of intelligence but of an intelligence that is not yet operational. The child encounter object by moving and touching without previous thought. As the child interacts with his surroundings, he slowly learns to handle it better. While the elementary school teacher is not involved directly with children in this stage, psychologists believe that many fundamental, foundational learning experiences occur during this period.

Toward the end of this period, child is able to imagine. He can call to mind certain people, animals, objects and activities. By age two, he has "names" for many things and activities, enabling him to elaborate his concepts in the next stage. Even at its highest level sensory-motor intelligence acts like a slow-motion film, in which all the pictures are seen in succession but without

fusion, and so without the continuous vision necessary for understanding the whole. Sensory motor thought is an intelligence in action and in no way reflective.

THE PRE-OPERATIONAL STAGE (2-7 years)

The Intutive Stage - Child Stimulus limited

This stage is called pre-operational because the child is not yet capable of carrying on any mental or logical operations like adding, subtracting, multiplying, dividing, correspondence, placing in order, subtituting, reversibility etc. The child in this stage is also unable to do certain "Infralogical" operations as well. Piaget considers infralogical operations to be mental processes below operations in the degree of mental sophistication and development required. They include observing, measurement, quantity, time, classifying, space, interpersonal reactions, values etc. The preoperational child differs from the sensory-motor infant by being able to internalize actions. In a sense, he thinks of moving an object before he moves it. The preoperational stage can be divided into two substages that of Preconceptual thought from two to four years and intutive thought from four to around seven. The "Preconceptual thought" can be described as, if adults reason either deductively from the general to the particular or inductively from the particular to the general, the child during this period reasons transductively from the particular to the particular. The "intuitive

thought" can be described as the thought that has not yet freed itself from perception. During intuitive stage he begins to sense the difference between such things as an individual item and its class, singular and plural, this glass and these glasses, man and men. When the child internalizes actions, he no longer operates just on stimuli from the environment, although his mental images or representations are limited to what he has experienced. One general characteristic of preoperational thought is 'egocentrism' . In its more exaggerated form, egocentrism is seen in children's ideas about various natural phenomena. The pre-operational child centres his attention usually on the surface of the problem. The superficial features may stimulate him the most. He centres only on one aspect of the change. In this stage child cannot combine a series of events to show how the changes they have undergone unify them. A child at this stage doesn't reverse his thought processes. The understanding of chance and probability is also absent. Most of his beliefs are arbitrary and have not been derived from reason. During this stages, the child's impression of time changes from thinking of the immediate present to thinking of future and past.

THE CONCRETE OPERATIONAL STAGE (7-11 years)

The Child is able to Perform Operations

During the concrete operational stage, a child slowly develops his ability to perform all of the logical

and infralogical operations. Manifestation of this cognitive potential is a major objective of elementary instruction, particularly in the sciences and mathematics. Concrete operational thought is mainly limited to thinking about things and objects rather than concerned with performing abstract reasoning. In this period child is able to observe, judge and evaluate in less egocentric terms and formulate more objective explanations than in the preoperational stage, but even now he cannot verbally express hypotheses following a long series of related ideas, or if concrete referents are not available. He can go beyond individual things and think of groups. Since the concrete operational person can do reversible thinking, he is able, late in the stage, to classify objects and organism in an ascending as well as descending manner. The ability to form classes and groups and relate their characteristics to individual member enables a child to expand his mental activity greatly.

THE FORMAL OPERATIONAL STAGE (11-15 years)

Developing of Abstract, Reflexive Thinking

In this stage the child attains complete conceptual generality and achieves the capacity for "hypothetico-deductive reasoning". He is now able to accept any sort of data as purely hypothetical and to reason correctly from them. As Piaget himself puts it. "Instead of just co-ordinating facts about the actual world, hypothetico-

deductive reasoning draws out the implications of possible statements and this gives rise to a unique synthesis of the possible and the necessary". The formal operational student is stimulus free since he doesn't need an external stimulus to activate his thinking processes. In this sense he is liberated from immediate environment in directing his behaviour. As a consequence, he originates many of his own ideas, enabling him to particularly broaden his creative enterprise. One of the main characteristics demarking this stage is the student's ability to do reflexive thinking. He is now capable of thinking back over a series of mental operations, reflecting on them. In other words, he can think about his thinking. In the process of doing this, he represents his own mental operations by symbols. The formal operational student thinks in terms of many possibilities rather than being limited to the facts before him. He can think of ideals as opposed to realities, and he is capable of understanding probability theory. At this stage, students may demonstrate further propositional thinking and reasoning. He is more capable of thinking abstractly, e.g. in performing complex mathematical tasks. Professor Flavell summarizes the achievement of the formal stage as follows :

> In brief, the adolescent can deal effectively not only with the reality before him... but also the world of pure possibility, the world of abstract, propositional statements, the

> world of "as if". This kind of cognition is adult thought in the sense that these are the structures within which adults operate when they are at their cognitive best i.e. when they are thinking logically and abstractly.

Piaget has thus propounded a stage concept which is highly relevant to the education of children. It is, therefore, of great interest to investigate thinking in general and problem solving, in particular, in as many different situations as possible.

Why This Study?

It is essential to conduct such studies as they generate sound knowledge in the area of methodology of instruction. There is a wide spread impression among educationists that the present day learning of teaching science is basically wrong somewhere, as it suffers from many defects, chief among them being.

Firstly as it is bookish and almost examination bound, there is a feeling that the present day teaching of science does not conform to the spirit and real nature of science.

Secondly teachers of science try to cover their courses according to the syllabus, which is devoid of real learning science.

Thirdly as such there is no functional knowledge,

acquisition of skills, attitudes and appreciation.

Fourthly while learning and acquiring scientific knowledge, students hardly use their talents and tools. They fail to apply their knowledge to new, novel and unknown situations.

Lastly, it won't be far wrong to say that child is hardly at the centre of teaching learning process in our school programmes. Tested experimental curricula have yet to appear in this country.

REVIEW OF RELATED LITERATURE

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

There are large number of researches in the area of problem-solving and intellectual development. The main researches related to the present study are mentioned in this chapter under the following sub headings.

1. Studies on problem-solving method
2. Studies on relationship of intelligence with problem-solving and intellectual level of development.
3. Studies related to the relationship of the intellectual development with problem solving.
4. Studies related with stages of development using written Piagetian task.
5. Studies on stages of development.

Studies on Problem Solving Method

Haidbreder, E. (1928) in his title of study "Problem Solving in Children and Adults" found that reactions and sensitivity to problems increased from subjective attitude, to a more objective attitude. Whereas the general pattern of the solution became more explicit and definite, new rigidity set in with increasing age.

In 1950, Ayle, T. studied "An Investigation of Thought Processes of a Group of 14-Year Old During the Solving of a Scientific Problem" and found the following three indications :

(i) Able pupils do not solve problem in stages. In fact, they jump from stage to stage.

(ii) A problem become real for a person only when he has some rudimentery foresight of tentative solution.

(iii) A 'doing group' went further towards a solution than a thinking group.

Buswell, G.T. (1956) investigated "Patterns of Thinking in Solving Problems". His study indicated :

(i) The subjects experience difficulty in expressing concepts verbally which they had in fact acquired.

(ii) They do not estimate the answers before they start solving problems.

(iii) Their failure to distinguish between the relevant and irrelevant aspects of the problem attracts all

sorts responses. Variety rather than similarity in the sequence of thinking was the most striking and outstanding characteristic even when common and uniform patterns of thinking were seen during the entire act of problem solving.

Polya, G. (1957), in his investigation "How to Solve it" found that the problem solving performance may be improved by making the children conscious of their thinking. 'Questions' and 'directions', apparently much like the heuristic questions and suggestions to stimulate students for analysing their own thinking are helpful in problem solving.

Mealings (1961) investigated some aspects of problem solving in science. He concluded the following results :

(i) Problem solving in science is more related to intelligence than to chronological age.

(ii) There appears to be a minimum mental age of 13 years before a child can reason formally about a problem.

(iii) Children should not be expected to solve abstract problems below the mental age of 16 plus.

(iv) There is a time lag between the empirical solution and formal solution.

Gunnels, F.G. (1967) in "A Study of the Development in Logical Judgement in Science of Successful and Unsuccessful Problem Solvers in Grades Four Through Nine" found that

use of formal reasoning in problem solving of science is dependent on age, mental age, and grade. Stage concept in thought develops sequentially is confirmed.

Wonzy, C.W. and Cox, D.C. (1975) in his study, "The Effect of Task Differences on the Assessment of Formal Operational Thinking" found that age definitely interacted with the number of variables. A problem becomes more difficult for the adolescent pupils to solve if more variables are injected into it.

Klein, G.A. and Weitzenfeld, J. (1977), in their study "General Description of Human Problem Solving", problem solving is defined as two simultaneous processes: The generation and evaluation of alternative that will accomplish what is needed, and the reidentification of what is needed on the basis of the experience of generating and evaluating the alternatives. It is concluded that this approach integrates inferential activities, long term memory, and the management of a limited capacity operational memory into a general account of problem solving.

Dunlop, D.L. and Frank, F. (1977), in their investigation "A Comparison of Student Performance in Problem Solving Tasks Within a Piagetian Setting". 116 science students between the ages of 15 and 22 were administered on 18-item abstract preference survey and three different problems. There was a similarity in

performances of males and females. On 'fossils' and 'electrical circuit' problems, the shift of preference was from a concrete mode to an abstract mode. On the 'balance' problem the shift of preference was from abstract to concrete.

Allowood, C.M. and Montogomery, H. (1979) in their study "Detection of Errors in Statistical Problem Solving" noticed that, students were given general instructions on how to proceed in various situations while solving the two given statistical problems. Some of these instructions asked student, after each sub step of problem solving, to check in various ways the solution of the previous sub-step. Students eliminated 25 out of 56 errors when they solved the problems. The thinking-aloud data indicated that students eliminated their own errors by (a) spontaneous discovery, (b) noticing that computations resulted in extreme values, (c) discontent with other aspects of a solution than the value of an answer, or (d) repeating a solution.

Studies on Relationship of Intelligence with Problem Solving and Intellectual Level of Development

Vaidya, N. (1964) in his title "A Study of Problem Solving in Science Among Certain Groups of Adolescent Children", using questionnaire approach (N = 60) as well as interview approach (N = 31), found adolescent boys of two schools in central London, (i) Solving a given problem over a wide I.Q. range not only within a given age group but also across the various age groups, (ii) Though adolescent pupils are in a position to state hypotheses most of them are not in a position to test them, (iii) They do not, contrary to Piaget, exhaust all possibilities.

Yudin, L.W. (1966) in the study "Formal Thought in Adolescence as a Function of Intelligence", contrary to Piaget, show concrete thinking behaviour as defined by Piaget. Added age is an important factor in the development of formal thought.

Bart, W.M. (1971) in his investigation "The Factor Structure of Formal Operations" investigated that when four Piagetian formal operation tasks, three formal operational reasoning tests (in each of three content areas biology, history and literature) and a test of verbal intelligence were administered to 90 adolescents (30 at each of three age levels 13, 16 and 19 years), and factor analysed, eight measures appeared which had bifactor

structures, which distinguished tasks from tests.

Misra, R.K. (1973) investigated the role of hypotheses in problem solving among grade X students. His study indicated that there is no sex difference between the top group and the bottom group on the number of hypotheses emitted by them. It was also found that problems were solved over a wide I.Q. range i.e. a low I.Q. pupil may solve the problem successfully where as high I.Q. pupil may fail to do so.

(iii) Many adolescent pupils experience difficulty in testing hypotheses.

Cloutier R. and Goldschmid, M.L. (1976) in the study of "Individual Differences in the Development of Formal Reasoning" found that significant correlations have been obtained between scores on the proportion test and non-verbal intellectual capacity as measured by the Raven's RPM.

Gamoke, P.K. (1978) in the study "A Structure of Intellect Analysis of Some Piagetian Formal Operation Tasks : A Developmental View". Four hundred and fifty two high school students, age ranging from 131 to 227 months were administered two Piagetian Tasks and 12 structure of intellect tests suggested by Guilford. A factor analysis of the structure of intellectual abilities with the Piagetian Formal Operation tasks revealed that the

differentiation of the structure of the intellect occurs mainly during the early concrete Piagetian stage of development. The integration of the structures of the intellect occurs mainly during the formal Piagetian stage.

Studies Related to the Relationship of the Intellectual Development with Problem Solving

Abramowitz, S. (1975) in his study "Adolescent Understanding of Proportionality Skills Necessary for its Understanding" found that the nature or the content of the problems definitely mars the performance of the transitional thinkers between the concrete and the formal stage on the scheme of proportionality.

Morin, Joseph, G. (1978) studied "The Relationship between Students Intellectual Development and their Ability to Solve Problems Requiring Formal Thinking Abilities" Fifty two high school science children were administered a paper and pencil 'Piagetian tasks' type instrument and the subjects were classified in early concrete, concrete, early formal and formal level. Two chemical concentration problems which were based on the formal thinking abilities were administered, overall results indicated that formal subjects performed better on the concentration tests than early formal subjects, early formal subjects performed better than concrete subjects and concrete subjects performed better than the early concrete subjects.

Gartland, M.J. (1978) studied "The Relationship of Problem Finding to Selected Formal Operational Piagetian Tasks in Middle Adolescents". When ninety children (44 male and 46 female) of grade 10, 11, 12 were administered individually, a problem-finding task and three Piagetian tasks : Combinatorial operations, Conservation of motion, Mechanical equilibrium, the difference in the level of attainment on the three Piagetian tasks was significant among the high problem finders. Problems finding did not appear to be dependent upon sex, age, or developmental level, and did not appear to possess the stage characteristics of Piagetian theory.

Vaidya, N.(1979) studied "The Growth of Logical Thinking in Science During Adolescence" and found that (i) The complex thinking processes arise from simple thinking processes, (ii) Except occasional fluctuations, the mean performances on the various schemes of thought shows an increasing trend with grade, (iii) In case these fluctuations are taken seriously, hump effect is suspected, (iv) Where as the adolescent pupils are in a position to set up hypotheses, they are not in a position to test them contrary to Piaget's view.

Jain, S.C. (1982) in a doctoral study on "A Study of the Problem Solving Behaviour in Physics Among Certain Groups of Adolescent Pupils" investigated adolescent

problem solving behaviour in Physics and found :

(i) Out of 180 students only 36 percent are at formal level, 46% are at post-concrete level and 18 percent are still at concrete level;

(ii) After providing hints, a large number of initially non-problem solver students solve most of the problems;

(iii) Among the three groups differing in creativity, no significant difference for problem solving ability scores was observed.

(iv) Significant relationship exists between the scores of total problem solving ability and the each problem scores.

(v) Among the groups differing in I.Q., Creativity and level of intellectual development, no sex difference were noticed.

Shrestha, S.B. (1983) in the study "The Acquisition of Problem Solving Processes During Adolescence" found that (i) mean scores on individual processes of thinking within any problem show an increasing trend with age and grade, (ii) Largest number of errors were confined on rectangle problem whereas least number of errors on positive constant difference problem, (iii) In comparison to girls, boys are better problem solvers.

Studies Related with Stages of Development Using Written Piagetion Task

Karplus, R., Karplus, E., Forminsano, M., and Paulsen, A. (1975) in their study, "A Proportional Reasoning and Control of Variables in Seven Countries", found that two written Piagetion task, Proportional reasoning and control of variables were administered to about 3600 boys and girls in seven countries, ranging in age from 13 to 15 years.

Adi, Helen, Karplus, R., Lawson, Anton, and Pulos, Stephen (1977) in the study of "Intellectual Development Beyond Elementary School VI : Correlational Reasoning, Advancing Education through Science-oriented Programs" found that 80 ninth and twelfth grade students (Mean age = 14.7, 17.5 years respectively) were administered either the causal or co-incidental task. The performance on co-incidental task was better than causal task and the difference was significant.

Shayer, M. and Wylam, H. (1978) in a study "The Distribution of Piagetian Stages of Thinking in British Middle and Secondary School Children 14 to 16 years olds" found that different Piagetian levels of thinking was measured on 1200 children, age range 15 to 16 years. The girls performance was substantially low on the test on relationships, on volume and density.

Karplus, R., Adi, Helen, and Lawson, A.E. (1978) "Intellectual Development Beyond Elementary School VIII : Proportional, Probabilistic and Correlational Reasoning, Advancing Education Through Science-oriented Programs" noticed that test consisting of 6 items based on proportion, probability and correlation reasoning was administered to 505 students from sixth grade to college level, ranging in age from 11.5 to 20 years. The findings on proportion item indicates that most of the sixth graders used additive procedures while the majority of upper middle class and other higher grade students used proportional reasoning. On probability item the performance increased from 23 per cent in grade sixth to 79 per cent in the college. None of the sixth grades gave evidence of correlational reasoning but 50 per cent of the college students did.

Walker, R.A., Hendrix, J.R. and Mirtens (1979) in the study of "Written Piagetian Task Instrument : Its Development and Use" found that a written Piagetian test of six tasks based on proportional, combinatorial and hypothetico-deductive logic was administered to about 96 students at the age of 15 years. Pretest results indicate that 62 (72%) were at formal level and 24 (28%) were either at concrete or post concrete level. Following a 3 week interval post test indicated 19 per cent increase in the number of formal level students.

Studies on Stages of Development

Inhelder, B. and Piaget, J. (1958) in their study, "The Growth of Logical Thinking" : From Childhood to Adolescence concluded that

(i) Concrete operational subjects can describe the results of their experiments but fail to hold other factors constant.

(ii) Formal operational subjects attempt to prove something through control experiments.

(iii) Considering experimentation elsewhere, they hypothesized setting and testing, behaviour does not become highly rampant.

Wheeler, D. (1958) in his "Studies in the Development of Reasoning in School Children" found that contradicts Piaget, he concluded that elementary schemata are very there even among young children. It is their subsequent development which describes the difference in performance between the young.

Peel, E.A.(1960) in his study "The Pupil's thinking", confirms Piaget in principle. Identifies four kinds of thinking, namely, thematic, explanatory, productive, and integrative.

Lovell, K. (1961) confirms Piaget in principle in his investigation "A Follow-up Study of Inhelder and Piaget's The Growth of Logical Thinking". It was found that the pupil's of low academic ability fail to develop

formal operations even past their mid-adolescence.

Beard, R.M.(1962), in his study of "Children's Reasoning" found that there are vast individual differences in levels of thinking among adolescent pupils studying in different schools. Previous classroom experiences appeared to play an important factor in the separation of variables.

Jackson, S. (1965) investigating in "The Growth of Logical Thinking in Normal and Sub-Normal Children" found that about half of the 15-year olds do attain the formal operational stage.

Wells, J. (1972) in his investigation "Some Aspects of Adolescent Thinking in Science" found that mental age rather than chronological age determines the quality of the thinking. However, a wide spread of mean was noticed both for C.A. and M.A. when thinking was classified in various ways : Describer level, Extended describer level Explainer, using analogy and using inference etc.

Lawson, A.E. and Renner, J.W. (1974) studied "A Quantitative Analysis of Responses to Piagetian Tasks and its Implications for Curriculum" and found that about 22 per cent of the college freshmen operate at formal operational level while 51 per cent and 27 per cent are found at the concrete operational and post-concrete operational level respectively.

Waits, J.B. (1975) in "A Study Comparing College

Science Students, Performance on Piagetian Type Tasks, Including Cross Cultural Comparisons" found that there is no direct bearing of varied cultural backgrounds on the performance of Piaget type tasks.

Clayton, V. and Overton, W.F. (1976) in the study of "Concrete and Formal Thought Processes in Young Adulthood and Old Age" noticed that there is variation in formal thought with age.

Martorano, S.C. (1977) studied "A Developmental Analysis of Performance on Piaget's Formal Operations Tasks" and concluded that mean scores on the ten tasks increase with grade.

Sandhu, T.S. (1980) in a doctoral study, on the "Factorial Study of Adolescent Thought" investigated adolescent thinking processes and found

(i) Performance on Piaget type tasks increases with age;

(ii) Boys perform either equal or better than girls on the tasks at respective age levels;

(iii) Significant correlation exists between intelligence and the adolescent thought and between academic achievement and adolescent thought.

Padmini, M.S. (1982) investigated in a doctoral study, on "The Growth of Exclusion of Variables During Adolescence". She found

(i) In all grades adolescent pupils are in a position to state and test hypotheses. However, with occasional fluctuation, the mean performance increases with grades.

(ii) Many adolescents are still found to operate at the concrete level.

(iii) The fourteen year olds are the successful problem solvers in majority and the majority of the unsuccessful problem solvers are the ten year olds.

Jain, A. (1984) studied "A Study of Piagetian Logical Thinking Among Certain Groups of Adolescent Pupils Using a Group Test", she found

(i) Mean performance on each scheme of thought increases with age.

(ii) Boys of Government schools and girls of private schools were superior in their performances on various schemes of thought.

(iii) The scheme of Proportion, Probability and Testing Hypotheses were partially developed even at the age of 15+ and 16+.

This study differs from the above mentioned studies in the following respects.

1. Sample (N = 150) is drawn from single girls' school.

2. In each sub sample (N = 25), girls of average achievement have only been included, their aggregated achievement ranging from 50 per cent to 59 per cent.

3. In each sub-sample, grade and age have also been controlled.

4. Several schemes of thought along with the errors committed during problem solving have been studied.

5. It has also been possible to determine the mathematical structure of the tests and tasks used in this study.

CHAPTER III

THE PRESENT STUDY

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Introduction

This study has been undertaken to investigate certain aspects of logical thinking through the medium of problem solving among average girls of adolescent age. The main aim of this study is to encounter errors as they occur during problem solving. In this context, past work is loosely defined which hardly influences each other because of the sheer physical limitations of availability. Hence a study was planned which evoked diverse problem solving behaviour over a wide age range through a series of problems, each inhering a continuous chain of reasoning, used individual mode of administering problems, included some outside variables and finally, had a compact sample matched on age, grade and intelligence. These problems are mostly Piagetian in flavour and involve the "Schemes of thought", using constant difference, using proportion, classification, conservation of volume,

probability, testing hypotheses, grasping the essence of the problem and stating procedures. It is in this context, the present study entitled :

> "Some Aspects of Logical Thinking within Piagetian Context Among Certain Groups of Average Adolescent Girls".

The Research Design

Aims and Objectives

The present study aims at investigating following :

1. To study thinking (Problem-solving) processes, evoked by individual problems, each containing a continuous chain of reasoning.
2. To study the same processes when appropriately grouped, regardless of the typology of problems.
3. To study errors as they occur in solving these problems.
4. To determine the relationships between scores on thinking and some outside variables : intelligence and age.
5. To analyse the structure of the appropriately grouped process of thought factorially and interpret them psychologically.
6. To point out the main educational implications based upon findings of the study.

Hypotheses to be Tested

The following hypotheses are proposed to be tested.

1. Poor problem - solvers are influenced more by the content rather than the form of the problem.

2. Complex problem-solving processes arise from simple problem-solving processes.

3. Scores on problem solving do not increase with age and grade.

4. Scores on various schemes of thought differ significantly from grade to grade.

5. There are significant correlations among all variables included in this study.

6. A mathematical picture for the various schemes of thought and other tests exists.

Method of Procedure

This section of the chapter provides an overall description of the methodology used in the present study. In all ten variables, 42 processes and data collected by the researcher are included in this study. The criteria used for selection of the institution, sample and tools used are as follows :

Criteria for Selection of the Institution and Sample

The first step of the present study was the selection of the school and sample. The investigator adopted the following criteria to select the school and sample.

(i) As this study was designed to control grade, age and I.Q. simultaneously, the school should provide good sample for the success of the present investigation. For administering the tests the investigator was free to select the schools randomly.

(ii) The availability of dates of birth of all students studying in different grades.

(iii) The convenience and cooperation of the school authorities in providing the necessary facilities for the administration of the tests was another factor taken into consideration.

(iv) Only the Higher Secondary Schools of Ajmer City having Hindi medium have been selected for the present study. The schools located in Ajmer City were selected by the investigator for the sake of convenience to visit the school as often as required for the present study. Further it was felt that the investigator herself should be able to administer the various tests in her presence so that the result obtained may be free from the individual differences (subjectivity).

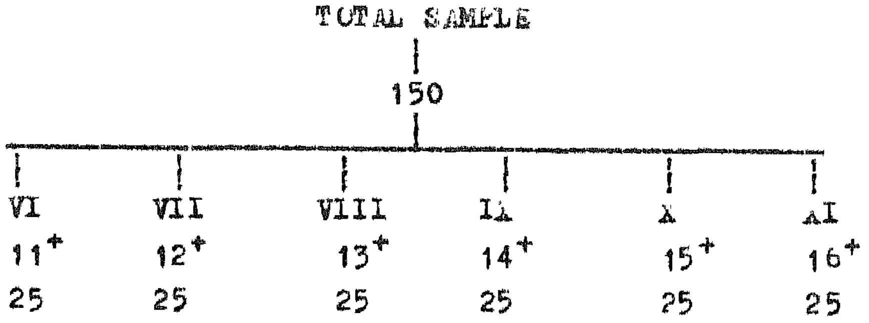
(v) Savitri Girls H.S. School of Ajmer City has been selected for the present study.

Sample and Subjects

Out of 900 students of grade VI to XI of Savitri Girls H.S. School, Ajmer a sample of 240 students was initially drawn on random basis in this field experiment. From each grade equal number of girls were taken. In order to obtain a homogeneous sample grade, age and I.Q. level

were controlled. On the basis of the dates of birth of the girls maintained in the Scholars' Register, only the students of 11.1 to 11.11, 12.1 to 12.11, 13.1 to 13.11, 14.1 to 14.11, 15.1 to 15.11 and 16.1 to 16.6 years corresponding to the grades VI, VII, VIII, IX, X, and XI were selected carefully.

For the measurement of intelligence, the Cattell's Culture-Free Intelligence Test, Scale II Form B was used, as the girls of average I.Q. level were required for this study. The individual raw scores and ages being known, the corresponding mental ages were read from the Table. All the intelligence quotients were thus computed and then on the basis of average I.Q. level, a sample of 150 girls was selected finally, for this study. Their I.Q.'s ranging from 89 to 110. All students appeared in the tests. The frame of the final sample is given as below :



Tools used

To study the proposed hypotheses for the present study, the tools for measurement of intelligence and thinking processes were selected. For measurement of intelligence the

Cattell's Culture Free Intelligence Test, Scale 2, Form B and for the measurement of different thinking processes the written Piagetian type test (Jain, M.1982) was applied. The description of these two tests are as follows :

Intelligence Test

As a large number of children would have to be covered within a short period of time, investigator preferred to use a group test of Intelligence. Further to avoid the problem of language comprehension, a non-verbal group test (Cattell's Culture-Free Test Scale 2, Form B) was used for the study. This test has been widely used in a number of investigations conducted in U.S.A., England, France, Italy and India.

Description of Intelligence Test

From research point of view, it always remains true that an exact and meaningful measurement of general intelligence is as important as the measurement of other variables. The Culture-free intelligence test aim to single out the most consistent core of basic mental capacity.

Culture-Free Intelligence Test was designed by R.B.Cattell and A.K.S. Cattell. This test is available in three levels : Scale I, Scale II and Scale III. Each scale has been prepared in two parallel forms A and B respectively. Four distinct types of relation education are balanced in four tests demonstrated to be of high "g"

saturation, these are Series, Classification, Matrices and Conditions. Scale II, Form B consists of the following four sub tests :

> Test 1 Series : Select the item which completes the series. This test consists of 12 items to be solved in 3 minutes.
>
> Test 2 Classification : Mark one of the items in each row which does not belong to that category. This comprises 14 items and the time duration for this test is 4 minutes.
>
> Test 3 Matrices : Mark the item which correctly completes the given matrix or pattern. In all there are 12 items in this test to be solved in 3 minutes.
>
> Test 4 Conditions : Insert a dot in one of the alternative design so as to meet the same condition indicated in the sample design. It consists of 8 items and time limit for this is 2½ minutes.

Reliability and Validity of the Test

The Test reliability has been evaluated both in terms of the Dependability Coefficient and the Consistency Coefficient. The Dependability Coefficient (Immediate test re-test agreement) on the full test for 200 American high school freshmen was 0.82 and on 450 eleven year old British Secondary School entrants, 0.85. The Consistency Coefficient (Splithalf, corrected to full length) has come out at .70, 0.86, 0.87 and 0.92 on four different groups.

Validity of the four types of sub-test range through .53, .66, .89 and .99, which is a very gratifying level for tests of such brevity.

Administration and Scoring

The test was administered in a group of 25 to 30 students at a time, proper instructions were given and the method was explained by using 2 or 3 examples.

Each correct item was awarded 1 mark and the total marks thus obtained is the "raw scores on Cattell's Intelligence Test. These raw scores were converted into I.Q. value from the classical norm Table 3 given in the Manual.

Written Piagetian Type Tasks

A large number of written Piagetian type of tasks were reviewed. Most of the tests are standardised and have been applied on American and British Children. Recently a test was prepared under the guidance of Professor Vaidya (Jain M., 1982) which was reasonably reliable and valid. Reliability and validity of the individual task are summarised in Table I.

Contd.

Table I

Coefficients of Reliability and Validity of the Test of Piaget Type Tasks

S.No.	Name of the Task	Reliability Coefficient N = 60	Validity Coefficient N = 60
1.	Height Problem	0.563	0.410
2.	Shadow Problem	0.907	0.591
3.	VIII Class Problem	0.624	0.436
4.	Beaker's Problem	0.866	0.755
5.	Beads Problem	0.486	0.331
6.	Questions inviting the wrong answer	0.668	0.278
7.	Numerical Problem	0.902	0.442
8.	Candle Problem	0.882	0.453
9.	Ball's Problem	0.806	0.638
10.	Card's Problem	0.700	0.492
11.	Meal Worm Problem	0.836	0.483
12.	Questions inviting the wrong answer	0.622	0.310

The reliability of the test here is ranging from .486 to .907 which is very high. The validity of the test is also ranging between .278 to.755 which is also very high. So the test was selected for the present study. Initially all the 16 problems were taken, but after discussion and consultation with the concerned expert, finally it was

decided to select 12 problems consisting of 42 processes for investigation.

Definition of Schemes of Thought

Here the term has not been used in the Piagetian context. It can be loosely defined as highly generalized concept in relation to quantitative knowledge drawn from the fields of Physical sciences. In this restricted respect, it shows some of the following characteristics :

(i) It is not simply an addition or substraction process applied mechanically. On the other hand, it is backed by reasoning.

(ii) Within the context of each problem, mastery over it and others in turn is likely to lead to the solution of the problem.

(iii) It is fundamental in character. In this light, each test item has been examined to determine whether it did constitute a thinking (Problem-solving) process.

(iv) And lastly, the number of thinking processes should not be unnecessarily, too large.

For carrying out this analysis, it became necessary to know how the solutions to the various problems grew. All the twelve problems were given the various thinking processes evoked were listed. The schemes of thought included in the problem solving processes of the present study are mentioned in the following Table II along with their corresponding contact thinking processes as well as the problems and number of processes.

Table 11

Schemes of Thought, Serial Number of Contact Problems as well as Process, Number of Processes and the Maximum Score Possible on the Various Schemes of Thought

S. No.	Scheme of thought	S.No.of contact problem	S.No. of Processes	Total No.of Processes	Maximum Score
1.	Using constant difference	1, 7	1,2,3,4,24, 25,26,27, 28,29	10	12
2.	Using Proportion	2, 8	5,6,30,31	4	6
3.	Classification	3	7,8,9,10, 11,12	6	6
4.	Conservation of volume	4, 9	13,14,15,32, 33	5	8
5.	Probability	5, 10	16,17,18,34, 35	5	6
6.	Testing hypotheses	11	36, 37	2	6
7.	Grasping the essence of the Problem	6, 12	19,20,21,22, 23,38,39,40, 41,42	10	12
8.	Stating Procedure	2,4,5, 8,9,10	-	8	16

The Individual Description of Problems

Each of the twelve problems are divided into Problem-solving processes. Their brief description is given below.

The symbol 'R' written against any one of the items means that it relates to the reading aspect of the problem, or alternatively, the answer to the test items based on this (R) processes is contained within the body of the problem itself. All such processes are not given process No. and have not been scored.

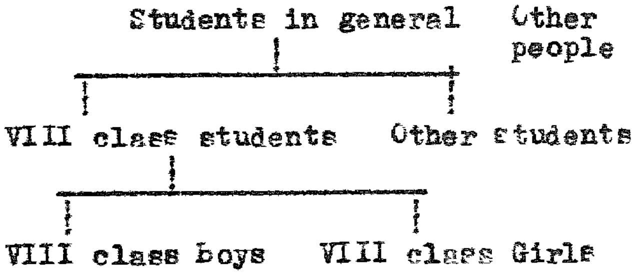
Problem No. 1 - Height Problem

S. No.	Statement of the Problem and the underlying process	Scheme of Thought	S.No.of scheme of Thought	Process No.	Scoring Key	Maximum Score	Variable No.used in the study
	Ram is taller than Shyam by 2 cms. Ram is taller than Mohan by 6 cms. Ram is shorter than Sohan by 6 cms. If Ram's height is 200 cms, then answer the following questions :						
1.	What is the height of Sohan?	Constant difference	I	1	0 any other 1 206 cm.	6	3
2.	What is the height of Shyam?			2	0 any other 1 198 cm.		
3.	What is the height of Mohan?			3	0 any other 2 194 cm.		
4.	How much is Mohan shorter than Shyam?			4	0 any other 2 4 cm.		

Problem No.2 - Shadow Problem

S. No.	Statement of the Problem and the underlying process	Scheme of Thought	S.No.of scheme of Thought	Process No.	Scoring Key	Maximum Score	Variable No. used in the study
	The heights of a building, a pole and a tree are 50 metres, 4 metres and 12 metres, respectively. If the length of the tree's shadow is 18 metres, then answer the following questions :						
1.	What will be the length of the shadow of the building?	Using Proportion	11	5	0 any other 1 75 cm.	6	4
2.	Give explanation of your answer			-	2 Explanation		
3.	What will be the length of the Pole's shadow?			6	0 any other 1 6 metre		
4.	Explain your answer.			-	2 Explanation		

Problem No.3 - VIII Class Problem

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring Key	Maximum score	Variable No. used in the study
	Look through the classification heierachy given below and with the understanding of it answer the questions given below : Fig. 						
1.	If VIII class boys and VIII class girls are grouped together, what name will you give to the group formed?	Classification	III	7	0 any other 1 VIII class students	6	5
2.	If VIII class boys are grouped with VIII class students and then both in combination are grouped with students in general, what name will you give to the group formed?			8	0 any other 1 Students in general		

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring Key	Maximum score	Variable No. used in the study
3.	If VIII class/students are grouped with students in general and then in combination are grouped with VIII class boys, what name will you give to the group formed?			9	0 any other 1 Students in general		
4.	If VIII class boys are grouped with a class without students what name will you give to the group formed?			10	0 any other 1 students in general		
5.	If VIII class boys are grouped with VIII class girls and then VIII class boys are taken out from the group, what name will you give to the group left behind?			11	0 any other 1 VIII class girls		
6.	If VIII class boys are grouped with VIII class boys, what name will you give to the group formed?			12	0 any other 1 VIII class boys		

Problem No.4 - Beaerks Problem

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring Key	Maximum score	Variable No.used in the study
1x	There are four beakers A,B,C and D. Beakers A and B are of the same size and volume and contains 100 c.c. of water each. Beaker C is broad and beaker D is narrow and long as shown in the diagram given below. Water from beaker A is poured into beaker C and water from beaker B to beaker D. Now answer the following questions :						
1.	What is the difference in the level of water in the beaker C and D?	Conservation of volume	IV	13	0 any other 1 The level of water in beaker C is lower than that of beaker D	6	6
2.	What is the difference in the quantity of water in beaker C and D?			14	0 any other 1 Equal		
3.	What is the difference in the volume of water in the beaker C and D?			15	0 any other 2 No difference		
4.	Explain your answer?			-	2 Explanation		

Problem No. 5 - Beads Problem

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring Key	Maximum score	Variable No. used in the study
	We have two bags A and B. Both the bags contain red and white marbles. Bag A contains 12 red and 20 white and bag B contains 33 red and 63 white marbles. Now, answer the following questions.						
1.	What is the total number of marbles in the bag A?	Probability	V	16	0 any other 1 bag A - 32	6	7
2.	What is the total number of marbles in the bag B?			17	0 any other 1 bag B - 96		
3.	In case we draw a handful of marbles from the bag without looking into it, from which bag is there a chance of drawing more marbles?			18	0 any other 2 bag A		
4.	Give reason for your answer?			-	2 Explanation		

Problem No. 6 - Questions inviting the wrong answers

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring Key	Maximum score	Variable No. used in the study
1.	A bale of cloth is ten metres long. It takes one minute to cut one metre of cloth. How much time will it take to cut off ten metres of cloth?	Grasping the essence of the problem	VII	19	0 any other 1 9 minutes	6	9
2.	A Handkerchief takes two minutes to dry up in the sun light. How much time it will take for twenty to dry up when placed in the sun at the same time?			20	0 any other 1 2 minutes		
3.	If we keep one kilogram of Iron on one pan of a balance, and one Kg. of cotton on the other, which of the two pans will be lowered and why?			21	0 any other 1 Equal		
4.	A Blind man with one eye can see upto a distance of 5 metres. How far does he see with two eyes?			22	0 any other 1 5 metres) 1 can't see/ 2		
5.	A man crosses a stream by a boat in fifteen minutes. How much time will it take for ten persons to cross the same stream in the same boat?			23	0 any other 1 15 minutes		

Problem No. 7 - Numerical Problem

S. No.	Statement of problem and the underlying process	Scheme of Thought	S. No. of Scheme of Thought	Process No.	Scoring key	Maximum score	Variable No. used in the study
	We have written some figures against each other in two columns. As you go down the columns, there appear some relationship. Try to understand it. Then fill in the blanks indicated by the question mark :						
1.	0 5	Using Constant difference	I	-	R	6	1
2.	5 10			-	R		
3.	10 15			-	R		
4.	(?) 20			24	0 any other 1 15		
5.	(?) 25			25	0 any other 1 20		
6.	(?) .... (?)			26	0 any other 1 25 and 30		
7.	-5 .... -10			-	R		
8.	-10 .... -15			-	R		
9.	-15 .... -20			-	R		

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring key	Maximum score	Variable No. used in the study
10.	-(?) ………… -25			27	0 any other 1 -20		
11.	-25 ………… (?)			28	0 any other 1 -30		
12	-(?) …………-(?)			29	0 any other 1 -30 and -35		

Problem No. 8 - Candle Problem

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of scheme of Thought	Process No.	Scoring key	Maximum score	Variable No. used in the study
	When a Jar is inverted over a lighted candle, it goes off within three minutes. This Jar has a volume of 2 litres. In case a Jar of 4 litres is inverted over the burning candle, answer the following questions :						
1.	In which Jar does the candle burn for less time?	Using Proportion	II	30	0 any other 2 Candle of 2 litre Jar	6	4
2.	For how long does the candle burn in the four litre Jar?			31	0 any other 2 6 minutes		
3.	Give reasons for your answers?			-	2 Explanation		

Problem No. 9 - Ball's Problem

S. No.	Statement of problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring key	Maximum score	Variable No. used in the study
	Two cylinders A and B of the same volume and size are kept on a table and water is filled in both upto the level 6 c.c. as shown in the figure given below. We have two spheres(balls) one of Iron and other of glass. They are both of the same volume and size but of different weight. When the Iron sphere put in cylinder A, the level of the water raises from 6 c.c. to 10 c.c. Now if we immerse the glass sphere in the water of cylinder B, then answer the following questions.						
1.	Will the water level in the cylinder B rise/fall/remain the same?	Conser-vation of volume	IV	32	0 any other 2 increases	6	6
2.	In case it changes, what will be the new level?			33	0 any other 2 upto 9 c.c.		
3.	Explain your answer?			-	2 Explanation		

Problem No. 10 - Joker Problem

S. No.	Statement of Problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring key	Maximum score	Variable No. used in the study
	There are four sets of cards. In the first set, there are 8 cards, which includes one joker. In the second set, there are 20 cards, which includes two jokers, in the third set, there are 36 cards, which includes 3(three) jokers and in the fourth set, there are 56 cards, which includes four jokers. There is the same design on the back of all these cards. Looking at the dig answer the following questions.						
1.	From which set is there more chance of getting the joker card?	Probability	V	34	0 any other 1 First group	6	7
2.	Give reason for your answer?			-	2 Explanation		
3.	If the card of the first and fourth, and the cards of the second and third sets are mixed then, from which set is there more chance of getting the joker card easily?			35	0 any other 1 First and third group		
4.	Give reason for your answer?			-	2 Explanation		

Problem No.11 - Meal Worm Problem

S. No.	Statement of Problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring key	Maximum score	Variable No.used in the study
	A student wanted to know how worms move about in Light and Moisture(Wetness). To solve this problem, he placed 16 works in the centre of each of the four glass boxes under different conditions of light and moisture. For moisture, water was sprinkled on the bits of paper in the whole box or in half the portion of the box as required Light was provided by the electric bulb to the required part of the box. After a day only, the worms move and change their places in the box. Look at the diagrams carefully and answer :						
1.	What do you conclude from the diagrams(1) and (3)?	Testing hypothe-sis	VI	36	0 any other 3 (2 Light+Dryness are equally Imp. (3 Light is Imp.	6	6
2.	What do you conclude from the diagrams (2) and (4)?			37	0 any other 3 (2 only dryness (3 Light+Dryness equally Important.		

Problem No.12 - Questions inviting the wrong answers

S. No.	Statement of Problem and the underlying process	Scheme of Thought	S.No.of Scheme of Thought	Process No.	Scoring key	Maximum score	Variable No.used in the study
1.	Suppose a donkey has two horns. How many horns in all have nine donkeys?	Grasping the essence of the problem	VII	38	0 any other 0 No horn 2 18 horns	6	9
2.	How many corners of the handkerchief are left if you cut off one of its corner with the help of a pair of scissors?			39	0 any other 1 5 corners		
3.	One metre long cord is tied to the neck of a cow, standing near a tree, how far the cow can go?			40	0 any other 1 any where		
4.	17 birds were sitting on a tree the hunter shot down one of them. How many birds were left on that tree?			41	0 any other 1 None		
5.	Some ducks are floating in the water. Out of them two are ahead, two in the middle and two at the back. Show at least how many ducks are floating in the water?			42	0 any other 1 4 ducks		

Total Score = 72

Administration of Questionnaire

Part I and Part II of the Test was administered in a group of 25 students at a time in each class. Regular classrooms were used to administer the test. Students were allowed to think as long as they required. It took about 40 minutes to 1 hour and 30 minutes in completing the test. Generally less time was taken by higher grade students in comparison to lower grade.

The test was administered on each grade separately. Students were asked to fill in the required informations mentioned on the first page of the test booklet. Then the attention of the students were drawn towards instructions which were read out loudly by the investigator along with the examples, and students were asked to follow what is read in their test booklet. They were asked to raise their hands if they had any difficulty to proceed. After making sure that all pupils had followed what they are supposed to do, they were asked to go ahead with other problems.

Delimitations

The present study is delimited with regards to the following :

(i) Girls of grade VI to XI were considered ranging within the age limits of 11+ to 16+ years.

(ii) They were selected from the one Hindi medium school.

(iii) Girls selected were of average I.Q. ranging from 89 to 110.

CHAPTER IV

ERRORS COMMITTED DURING PROBLEM SOLVING
and
THE ACQUISITION OF PROBLEM SOLVING PROCESSES

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ERRORS COMMITTED DURING PROBLEM SOLVING
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THE ACQUISITION OF PROBLEM SOLVING PROCESSES

SECTION - A

Introduction

According to Piaget, a teacher, while teaching in the class, should not always insist on right answers alone, they should listen more and more to the inaccurate answers of their pupils and consequently improve their strategies and tactics of teaching based upon the knowledge, thus, gained. If we really want to know something about the nature of child thought, then we must look certain points stressed by Piaget in his studies of children's thinking. Piaget has never been specially interested in depicting, in a normative way, the various responses that may occur at particular ages. He has attempted to discover the underlying structures which give rise to children's responses. When he poses, to a five-year-old child, the

task of putting into serial order a set of ten graded sticks, he wants to find out how the child will go about handling the task. He is interested in the kinds of 'errors' the child may make in the kinds of groupings he may attempt, rather than only the final arrangement made by the child. Therefore Piaget tells us "how children typically do or do not think".

Prof. Jean Piaget, while working with Theophile Simon in Paris in 1920 to standardise a test of intelligence, found that children of a particular age commit almost similar type of error. In contrast of the general view that the number of errors diminishes as age increases, it is found that during the formal operational stage there is a spurt and the number of errors committed by the adolescents suffer a 'hump'. It is a fine coincidence that Prof. N. Vaidya (1975) too encountered 'hump' in the number of errors while investigating the errors committed by the students in solving some problems. He noticed a sudden increase in the errors with the increase in age during the formal-operational stage contrary to the expectations that the errors should go on diminishing with age. He raised certain issues concerning this odd phenomenon :

> Is it the case of an adolescent playing with figures thoughtlessly or arbitrarily in the hope of being favoured with good luck? Is it the case of lack of seriousness on his part?

> Is it a case of being caught between the horns of a dilemma and getting muk? Is it the case of hot chase trying hard to choose in haphazard directions as if in the manner of closing in on the problem? Does it illustrate that mastery of a thought process is through a path: Uphill, thorny and often erratic? Or does the adolescent regress as if on an adventurous Piagetian journey during which he is trying hard to educate out himself, thinking that the right path to concept development lies in flourishing on experimental failures, or a problem solving situation in which either understanding suffers a dip or errors a hump? Alternatively, is it a fact of rubbing his schemes of thought wrongly, especially when he has personal reservations about his self acquired knowledge in contrast to school learning which does not set right his firmly held self centred thoughts? Lastly is it the case that he chooses to be very romantic in his computations when confronted with a problem situation leading to a chaos?

These quests needed further clarification and were referred to Prof. J.S. Bruner for comments. Bruner (1976) stated :

> The type of error that you refer to, which we speak of as growth error, is one which a growing child tries out a new strategy although it is not well developed and uses it in place of an one which has been working well. It is errors of this sort which suggest to me the venturesomeness of learning during this early

> period, the human beings are willing to shift to a less certain and more powerful strategy, before they have it under control, in preference to one which is safe, sound and dull.

Some researches on reasoning in Europe and India have also revealed the same interesting phenomena.

Past Literature

It appears that Piaget and Inhelder (1977), Lovell and Ogilivie (1977), David Elkind (1977) and Dominowski and Duncan (1977) did encounter this phenomenon but missed referring to it in their studies. Martorano (1977) also encountered this phenomenon on the performance at some Piagetian tasks in her doctoral study 'Developmental Analysis of Performance on Piaget's Formal Operations Tasks' though she could not detect it.

In India Sandhu and Vaidya (1978), observed 'hump effect'. They found that the dominant errors (shared by more than 20% of the pupils) tend to increase with age before their frequency finally fell. According to them, it occurs when the pupils are at the transitory stage of mental development midway between concrete stage and the formal stage, i.e., at a point where, the distinction between the two, temporarily speaking becomes too difficult to discern.

Vaidya (1975), Vaidya and Sandhu (1978), Kansakar (1979), Sandhu (1980), Mathur, M. (1981), Padmini, M.S.

(1982) also noticed the 'hump effect' in their studies, on various schemes of thought i.e. insight, combinatorial, using constant difference, ratio and proportion grasping the essence of the problem and stating hypotheses etc.

The Present Study

In the present study also the 'hump effect' has been noticed on six schemes of thought i.e. Proportion, Classification, Conservation of Volume, Probability, Testing Hypotheses and Grasping the essence of the problem. No hump appeared on the dominant error of using constant difference. Hump effect has been hinted at when the incidence of given error increases with age. An error is said to be dominant when it is shared by more than 20 per cent of the pupils on few processes of thinking, even two to three dominant errors have also appeared.* The grade distribution for other errors has not been shown because their number is too small to discern any pattern, largely speaking. The data regarding the percentage of dominant error of the different grades with respect to the six schemes of thought are presented in Table III.

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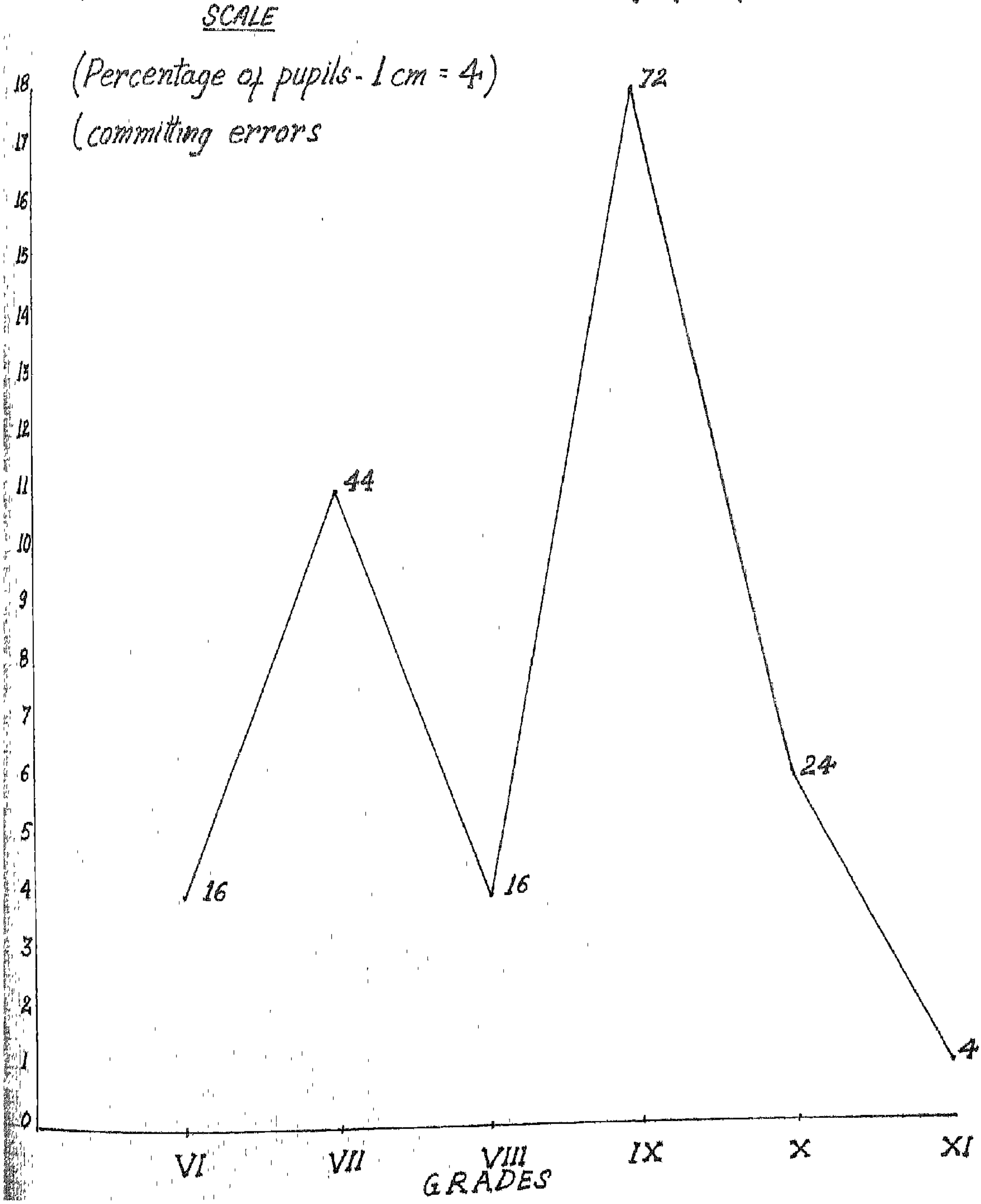
* Only the highest dominant error has been shown in Table III.

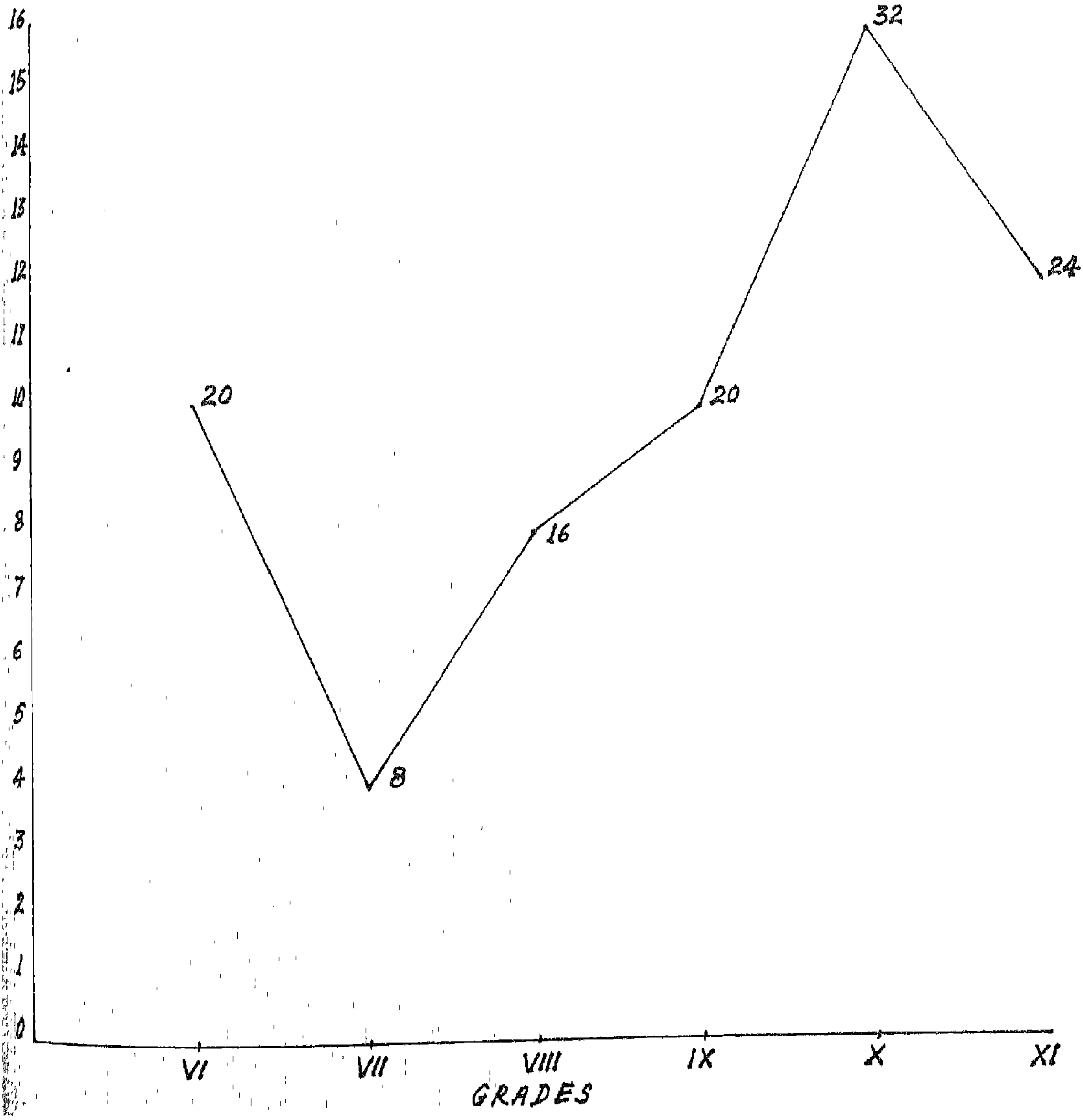
Hump of the dominant error on problem & process NO.2(6) of scheme of proportion



Hump of the dominant error on problem & process NO. 3(10) of scheme of classification

SCALE

(Percentage of pupils committing errors 1cm = 2)

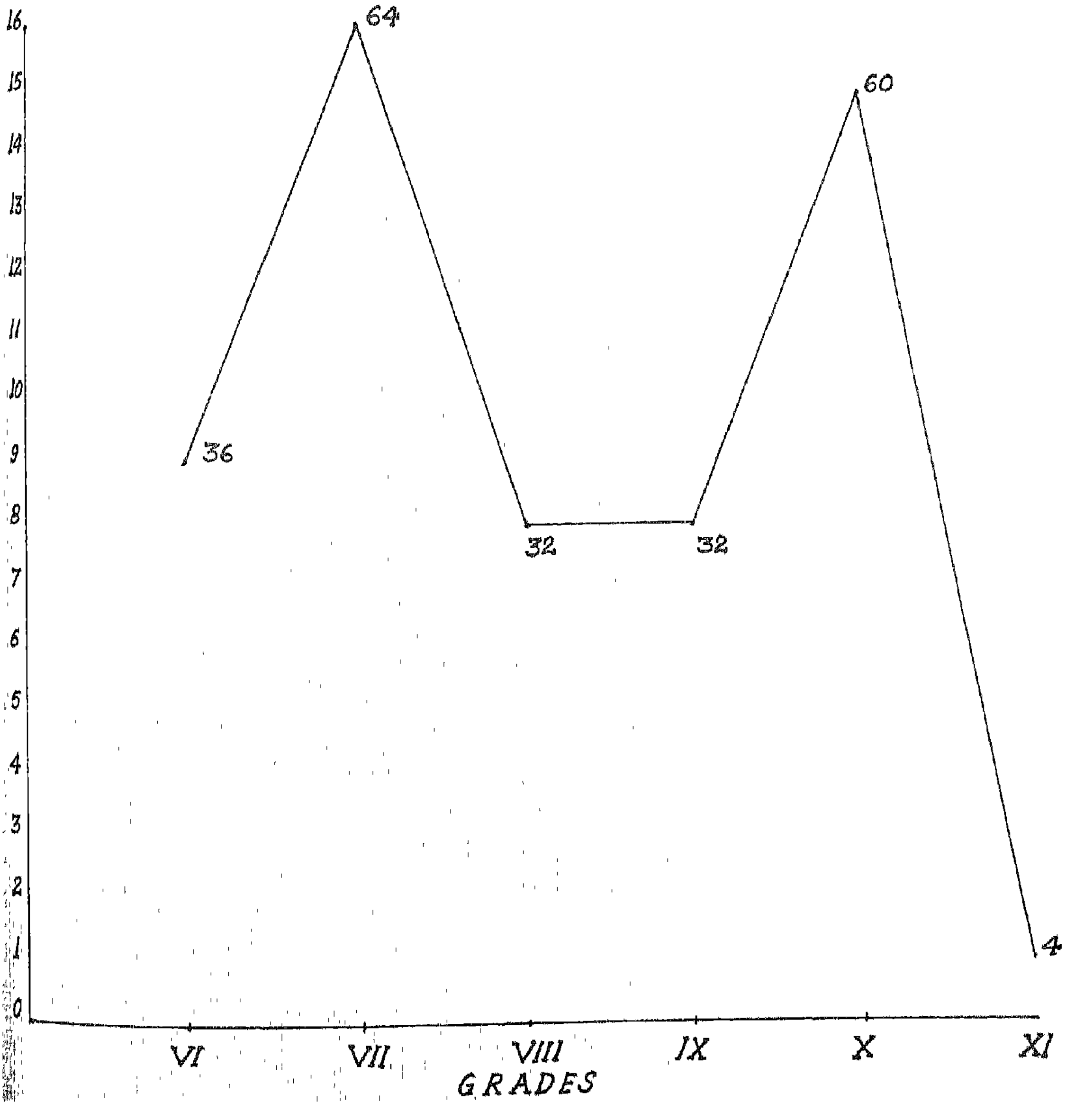


(GRAPH NO · 3)

Hump of the dominant error of problem & process No of conservation of volume 4(15)

SCALE

(Percentage of pupils commiting errors 1 cm = 4)

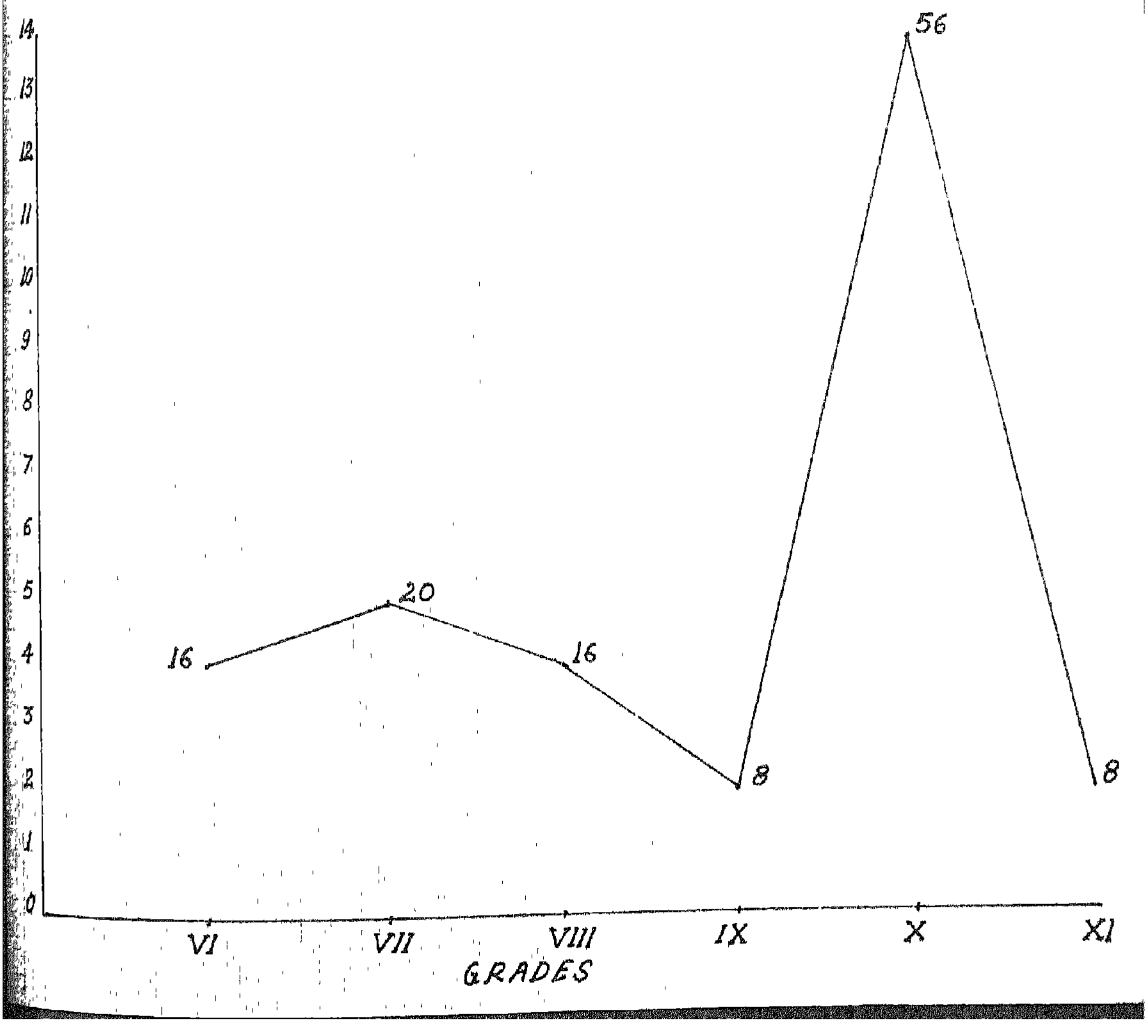


(GRAPH NO. 5)

Hump of the dominant error of problem & process No. 11(37) of testing hypotheses.

SCALE

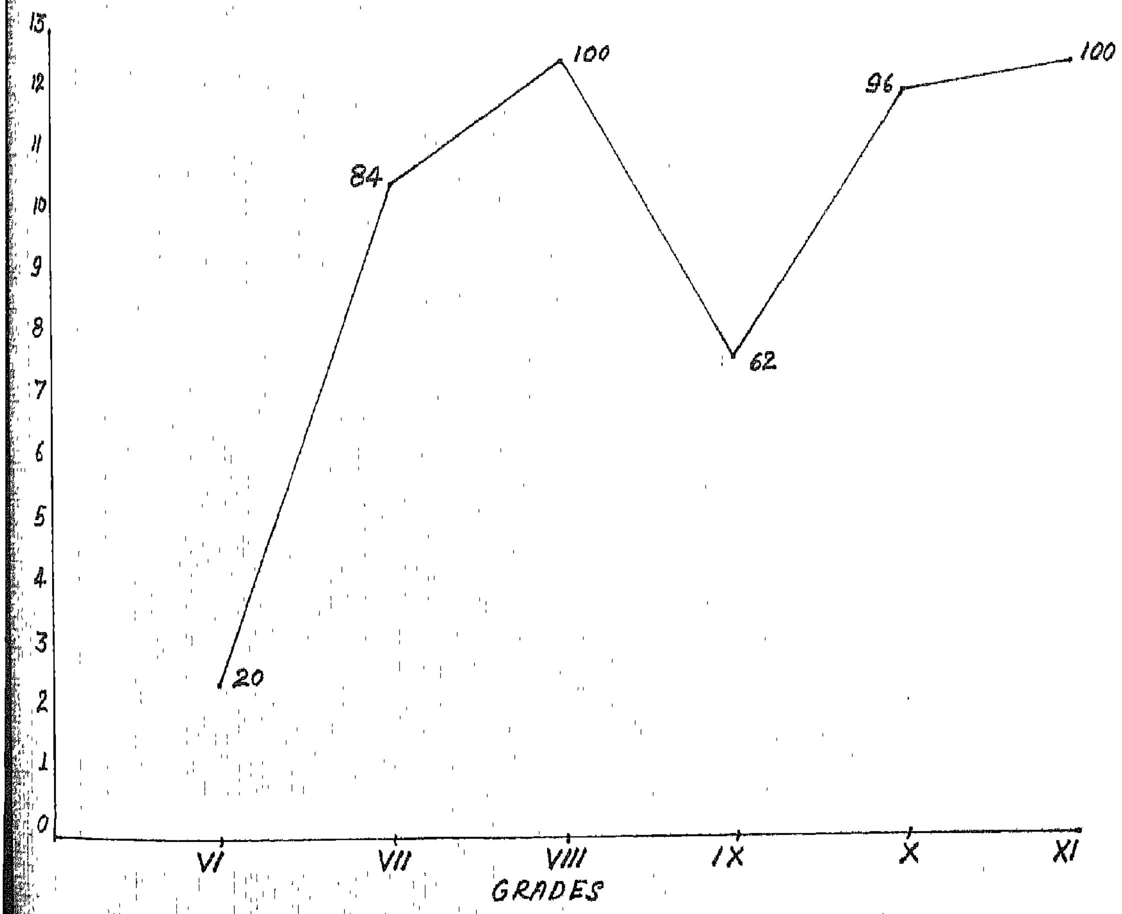
(Percentage of pupils committing errors 1 cm = 4)



Hump of the dominant error of problem & process No. 12(38) of grasping the essence of the problem.

SCALE

(Percentage of pupils committing errors 1 cm = 8)



More specifically, taking an entire view of this unusual phenomenon, Vaidya and Sandhu have suggested the following hypotheses for intensive investigation in their paper on : Hump Effect as observed During Problem Solving. These are :

1. Humps Effect appears when thought process moves from a lower stage to a higher stage, the most fruitful area for attack being the transitory period between any pair of the two succeeding stages.

2. It appears at all ages, choice of problems being the determining factor, among pupils at different levels of intellectual development when new concepts are under developments. It may appear in sex difference studies relating in achievement and intellectual deterioration among adults later on.

3. It is suspected that it may equally appear in the above mentioned context when :
   (i) Longitudinal studies on thought processes are undertaken.
   (ii) When thought processes are accelerated under controlled conditions.

4. Children stick to their thoughts firmly. When compelled to think, their erratic thought in several contexts appear to suffer hump before individual concepts finally settle down.

Interpretation of Table IV

(i) Pupils commit all sorts of errors, while they are involved in the Problem-solving procedure. The number of errors made on individual 42 processes of thinking (as listed in the table) are ranging from 1 to 12 on S.No. 5 and 21. Several ideas come to their mind, while thinking is influenced wholly by content of the problem. They think very hard while solving even questions needing restricted thought (S.No.38 and Process No.38). There is abundant variety in their answers for which they appear to have strong reasons.

(ii) Errors as shown in the table have an overall tendency to decrease with grade which is an expected finding. For example, errors completely disappear in grade XI (S.No. 1, 20, 22, 23,24, 25, 26, 27, 28, 29, 31, 34, 35, 40 and 41). But before they decline, they suffer a hump. Once this is crossed, errors disappear.

(iii) Majority of adolescent pupils cannot suspend their answer (judgement) when they tackle a defective or incomplete question, a question whose answer is not available for the needed information is missing within the question itself. This again shows that they are, largely speaking, influenced more by the content rather than the form of the question (S.No. 9 and 10).

(iv) Failure to accept the problem results in all sorts of errors called arbitrary errors which, when pooled, suffer a hump of varying nature. Secondly, dominant error as defined in this study also suffer hump of varying nature. This confirms another finding that more than 90% of the adolescent pupils studying in grades VI to XI are not in a position to suspend a judgement or judge the incomplete nature of the question.

(v) Contrary to Piaget and as judged by high incidence of content influence, adolescent pupils are affected by the content of the question not only within grades but also across grades. Taking an overall average of the influence of content, the extent of influence declines with grade, a finding consistent with Piaget, the respective gradewise percentages being : 66.57, 51.04, 43.95, 32.57, 27.23 and 11.90 from grades VI to XI. This suggests a fruitful hypothesis. When the choice of the problem is appropriate, the adolescent pupils do not hesitate at all to bring into the problematic situation several extraneous considerations. But when they are fail to solve the problem, the inferior one comes into play, bringing in its train, comments, criticisms and other arbitrary errors into the problematic situation.

On the basis of above interpretation, the Hypothesis one i.e. poor problem solvers are influenced more by the content rather than the form of the problem is accepted.

SECTION - B

Acquisition of Problem-Solving

The various processes of thinking are presented as evoked in this study by analysing all the problems regardless of their topology needed to solve them for the entire sample (N = 150). The maximum frequencies for any one of the single thinking processes within any one of the grades as well as for all the grades put together are 25 and 150 respectively. The extent to which a particular thinking process is present is not shown but it can be safely inferred, when all the thinking processes are seen together. The data has been presented below in Table V for the forty two thinking processes which have been put in the descending order of acquisition and for each individual thinking process, its serial number has been retained. With this step, the serial numbers of problems as well as those of the schemes of thought have been retained as intact.

Interpretation of Table V

Within the context of the problems selected in the study as well as the schemes of thought, it appears that complex problem solving processes emerge from simple problem solving processes. This view point comes out very prominently because the test item relating to the scheme of proportion is shared by most of the girls. The other difficult items take different serial numbers. This also applies to scheme of constant difference, Probability, Grasping the essence of the problem, Classification, Conservation of volume and Testing hypotheses. Regarding testing hypotheses the other test item relating to this scheme of thought comes or appears at serial No. 28 and 29 as the problems inhere a continuous chain of reasoning, it is difficult to comment on the fixed sequence of problem solving behaviour. If certain fluctuation are ignored and criteria kept at 50% level of acquisition, the following statements are made :

(i) About 50% of the girls do not have experimental minds. Girls from grade VI to VIII and X are not in a position to test hypotheses.

(ii) More than 50% of girls fail to grasp the essence of the problem.

(iii) The same observation applies to the schemes of thought, grasping the essence of the problem, conservation of volume, classification and

probability. Lastly, it may further added that only 19% of the girls are in a position to accept the absurd premises of the problematic situation or in other words they are in a position to reason formally.

It is, therefore, inferred that complex thinking processes arise from simple thinking processes. Hence, Hypothesis Two that "Complex problem solving processes arise from simple problem solving processes" is accepted.

CHAPTER V

STATISTICAL ANALYSIS AND INTERPRETATION OF THE DATA

CHAPTER V

STATISTICAL ANALYSIS AND INTERPRETATION OF THE DATA

Introduction

The tests selected for the present study were administered and scored according to the procedure as mentioned in the third chapter. The original data for all the variables for each student are presented in the tabular forms (Appendix IV). The present Chapter deals with the descriptive statistical analysis such as Mean, Standard Deviation and t-values to test the hypotheses 3rd and 4th. These statistics including correlation matrix and factor analysis were computed from statistical package for the social sciences - 'Version 5.01 Computer' at Council for Social Development, New Delhi.

Table VI

Gradewise, Mean and S.D. of each Scheme of Thought

S. No.	Schemes of Thought	Mean S.D.	VI	VII	VIII	IX	X	XI
1.	Using Constant difference	Mean	4.48	8.48	6.80	9.44	11.32	11.16
		S.D.	3.73	4.42	4.77	3.53	1.46	1.67
2.	Using Proportion	Mean	2.80	3.00	3.60	3.80	5.20	5.56
		S.D.	1.52	1.32	1.15	1.78	1.41	0.82
3.	Classification	Mean	1.00	1.80	2.72	4.12	3.84	4.44
		S.D.	1.19	1.22	1.37	1.33	1.10	1.32
4.	Conservation of volume	Mean	1.44	2.80	2.40	3.44	4.52	6.76
		S.D.	1.63	1.52	2.06	2.34	1.66	1.45
5.	Probability	Mean	2.56	3.16	3.64	4.44	4.24	5.04
		S.D.	1.38	1.28	1.03	1.26	0.87	0.97
6.	Testing Hypotheses	Mean	1.44	1.20	2.28	4.44	2.64	5.16
		S.D.	2.61	2.44	2.90	2.61	3.04	2.03
7.	Grasping the Essence of the Problem	Mean	2.84	4.24	5.56	6.04	6.04	9.64
		S.D.	1.17	1.64	1.53	1.51	1.81	0.70
8.	Stating Procedure	Mean	1.56	3.52	5.40	6.80	8.72	13.12
		S.D.	2.20	2.25	3.10	3.55	2.82	2.58

Interpretation of Table VI

1. Mean scores on each scheme of thought show an increasing trend with occasional fluctuation with age and grade, which is an expected finding.

2. The data show a dip in means within the overall growth in some of the grades in the scheme of using constant difference Classification, Conservation of Volume and Testing hypotheses. This is due to hump effect. It appears in some of the grades perhaps due to the divergent thinking of children at the adolescent age, as mentioned in Chapter IV also. The real reasons are difficult to ascertain.

3. The initial performance on various schemes of thought remains quite heterogeneous throughout the grades for the entire sample on some of the schemes of thought. However, the same becomes remarkably less in the closing grades.

Hence, the third hypothesis that scores on problem solving do not increase with age and grade is partially accepted.

Table VII

Showing Mean, S.D. and t-values of Using Constant Difference Between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No. of cases	Mean	S.D.	't' values
1.	VI	25	4.48	3.73	3.45**
	VII	25	8.48	4.42	
2.	VII	25	8.48	4.42	1.29
	VIII	25	6.80	4.77	
3.	VIII	25	6.80	4.77	2.22*
	IX	25	9.44	3.53	
4.	IX	25	9.44	3.53	2.46*
	X	25	11.32	1.46	
5.	X	25	11.32	1.46	0.36
	XI	25	11.16	1.67	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table VII

The results from the above Table shows that girls of grade VIII and IX and IX and X differ significantly in their mean performances on scheme of constant difference at .05 level and girls of grade VI and VII differ at .01 level of significance. There is no significant difference between the girls of grade VII & VIII and X & XI on this scheme of thought.

Table VIII

Showing Mean, S.D. and t-values of Scheme of Proportion Between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No. of Cases	Mean	S.D.	't' values
1.	VI	25	2.80	1.52	0.49
	VII	25	3.00	1.32	
2.	VII	25	3.00	1.32	1.71
	VIII	25	3.60	1.15	
3.	VIII	25	3.60	1.15	0.47
	IX	25	3.80	1.78	
4.	IX	25	3.80	1.78	3.08**
	X	25	5.20	1.41	
5.	X	25	5.20	1.41	1.10
	XI	25	5.56	0.82	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table VIII

The result shows that the girls of grade IX and X differ in their mean performances at .01 level of significance. While the other girls of different grades do not differ at any level of significance in their mean performances on the scheme of Proportion.

Table IX

Showing Mean, S.D. and t-values of Scheme of Classification between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grade	No. of cases	Mean	S.D.	't' values
1.	VI	25	1.00	1.19	2.34*
	VII	25	1.80	1.22	
2.	VII	25	1.80	1.22	2.50*
	VIII	25	2.72	1.37	
3.	VIII	25	2.72	1.37	3.66**
	IX	25	4.12	1.33	
4.	IX	25	4.12	1.33	0.81
	X	25	3.84	1.10	
5.	X	25	3.84	1.10	1.74
	XI	25	4.44	1.32	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table IX

The above Table shows that girls of grade VI & VII and VII & VIII differ significantly at .05 level in their mean performances on scheme of Classification, while the girls of grade VIII and IX differ at .01 level of significance on this scheme of thought. Girls of grade IX and X and X and XI do not differ at any level of significance. Their mean performances, however, different but they are not statisticall significant.

Table X

Showing Mean, S.D. and t-values of Conservation of Volume between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No. of cases	Mean	S.D.	't' values
1.	VI	25	1.44	1.03	3.04**
	VII	25	2.80	1.52	
2.	VII	25	2.80	1.52	0.78
	VIII	25	2.40	2.06	
3.	VIII	25	2.40	2.06	1.60
	IX	25	3.44	2.34	
4.	IX	25	3.44	2.34	1.88
	X	25	4.52	1.66	
5.	X	25	4.52	1.66	5.08**
	XI	25	6.76	1.45	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table X

The above Table shows that girls of grade VI and VII and X and XI differ in their mean performances at .01 level of significance. While the other girls of grade VII & VIII, VIII & IX and IX & X do not differ in their performances on Conservation of Volume at any level of significance.

Table XI

Showing Mean, S.D. and t-values of Scheme of Probability between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No.of cases	Mean	S.D.	't' values
1.	VI	25	2.56	1.38	1.59
	VII	25	3.16	1.28	
2.	VI	25	3.16	1.28	1.46
	VIII	25	3.64	1.03	
3.	VIII	25	3.64	1.03	2.45*
	IX	25	4.44	1.26	
4.	IX	25	4.44	1.26	0.67
	X	25	4.24	0.87	
5.	X	25	4.24	0.87	3.04**
	XI	25	5.04	0.97	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table XI

The result shows that there is significant difference in the means of grade VIII and IX at .05 level and means of grade X and XI differ at .01 level of significance. Girls of grade VI & VII, VII & VIII and IX & X have no significant difference in their mean performances on the scheme of Probability at any level.

Table XII

Showing Mean, S.D. and t-values of Testing Hypotheses between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No.of cases	Mean	S.D.	't' values
1.	VI	25	1.44	2.61	0.33
	VII	25	1.20	2.44	
2.	VII	25	1.20	2.44	1.42
	VIII	25	2.28	2.90	
3.	VIII	25	2.28	2.90	2.76**
	IX	25	4.44	2.61	
4.	IX	25	4.44	2.61	2.24*
	X	25	2.64	3.04	
5.	X	25	2.64	3.04	3.44**
	XI	25	5.16	2.03	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table XII

The results from the above Table shows that girls of grade IX and X differ significantly in their mean performances on testing hypotheses at .05 level and girls of VIII & IX and X & XI have significant difference at .01 level. While the girls of grade VI & VII and VII & VIII although differ in their mean performances, but this difference is not significant statistically.

Table XIII

Showing Mean, S.D. and t-values of Grasping the Essence of the Problem between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No.of cases	Mean	S.D.	't' values
1.	VI	25	2.84	1.17	3.47**
	VII	25	4.24	1.64	
2.	VII	25	4.24	1.64	2.94**
	VIII	25	5.56	1.53	
3.	VIII	25	5.56	1.53	1.12
	IX	25	6.04	1.51	
4.	IX	25	6.04	1.51	0.00
	X	25	6.04	1.81	
5.	X	25	6.80	3.55	1.59
	XI	25	8.72	2.82	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table XIII

Results show that girls of grade VI & VII and VII & VIII have significant difference at .01 level in grasping the essence of the problem. While the girls of grade VIII & IX, IX & X and X & XI are more or less similar in their performances on this scheme of thought.

Table XIV

Showing Mean, S.D. and t-values of Scheme of Stating Procedures between the Girls of Grade VI & VII, VII & VIII, VIII & IX, IX & X and X & XI

S.No.	Grades	No.of cases	Mean	S.D.	't' values
1.	VI	25	1.56	2.20	3.11**
	VII	25	3.52	2.25	
2.	VII	25	3.52	2.25	2.45*
	VIII	25	5.40	3.10	
3.	VIII	25	5.40	3.10	1.48
	IX	25	6.80	3.55	
4.	IX	25	6.80	3.55	1.59
	X	25	8.72	2.82	
5.	X	25	8.72	2.82	5.75**
	XI	25	13.12	2.58	

Significant at .05 level = 1.98*
Significant at .01 level = 2.61**

Interpretation of Table XIV

The results from the above Table shows that girls of grade VI & VII and X & XI are different in their mean performances at .01 level of significance on Stating Procedures. While the girls of VII and VIII differ significantly at .05 level. There is no significant difference in the girls of grade VIII & IX and IX & X on this scheme of thought.

Conclusion

On considering the results of Tables VII to XIV, it is found that some girls of two comparative classes have significant difference in their mean performances at .05 and .01 levels on various schemes of thought i.e. Constant difference, Proportion, Classification, Conservation of Volume, Probability, Testing Hypotheses, Grasping the essence of the Problem and Stating Procedures. But at the same time it is also found that some girls of two comparative classes have no significant difference on these schemes of thought, neither at .05 level nor at .01 level. Therefore, it is concluded that in some cases there is significant difference in mean performances of girls, while in some cases there is no significant difference in their mean performances on various schemes of thought.

Hence, the hypothesis four i.e. Scores on various schemes of thought differ significantly from grade to grade is partially accepted. Still the problems selected for this study are developmental in character. It should not be lost sight of that a given problem or a part of it is solved over a wide age range and I.Q. range not only within the grades but also across the grades too. Secondly, a problem should be studied according to Piaget, in its widest possible variation. Lastly, the Piaget type tasks inhering a continuous chain of reasoning are not easily amenable to the conventional techniques of item analysis etc.

CHAPTER VI

FACTOR ANALYSIS AND INTERPRETATION OF FACTORS

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FACTOR ANALYSIS AND INTERPRETATION OF FACTORS

Introduction

Factor analysis is a highly mathematical technique which extracts the minimum number of factors amidst several variables affecting given phenomena. Several methods of factor analysis are available and the choice of any method is a matter of personal convenience. In the present study, the technique chosen for factor analysis was the principal axes method. Within this wider context, several studies on adolescence thought are reported.

Some Related Studies

Vaidya (1964) investigated problem solving among certain group of adolescent pupils using questionnaire approach as well as individual approach, with the help of Piagetian type tasks and other variables : intelligence, age, test scores on Arithmetic and English, persistence,

maladjustment and interest in things in Central London. The data when factorially analysed by Hotelling method, revealed ten factors of which only the four factors namely, Attainment factor, Practical factor, Interest factor and Adjustment factor were found significant and were interpreted after rotation.

Vaidya (1975) some years later investigating a more elaborate study, using 45 variables on the growth of logical thinking during adolescence using seventeen problems and other tests, like intelligence, adjustment etc., on a sample of 200 students of grade VI to X found ten factors : Schematic learning, General adjustment, Problem orientation, Sensing problems, Symbolisation, Testing hypotheses, Using constant difference, Aspect character, Seeing the problem as a whole and Intelligence.

Sandhu (1980) investigated the structure of formal thought with the help of ten Piagetian type tasks and other variables : Intelligence, Reasoning ability, Space relations, Adjustment, Personality traits and Academic achievement on 986 adolescent pupils studying in grade VI to X. The factor analysis of data by the principal component method and then rotated by varimax showed the fourteen factors.

Padmini (1982) investigated the growth of exclusion of variables during adolescence on 200 students studying in grades VI to X using 39 variables. Stating and Testing

of hypotheses, Intelligence, HSPQ, and Aptitude tests, Permutations, Combinations, Problem sensitivity and Grasping the essence of the problem were administered and the following twelve factors were obtained using principal component method (Varimax rotation) : Language Factor, Exclusion of variables (Testing Hypotheses), Exclusion of variables (Stating Hypotheses), Super Ego Strength, Group Factor of Personality, Permutations and Combinations, Mechanical Reasoning, Self Sufficiency, Age, Parmia, Ego strength and intelligence.

Jain (1982) conducted a study of problem solving behaviour in Physics using 34 variables on a sample of 180 adolescent pupils studying in grade XI (Science). Using scree test last six factors were eliminated out of the existence of the twelve factors. The following six factors were interpreted psychologically : General Schematic learning, Creative thinking, Academic Achievement or Experience in Science, Probabilistic Reasoning, Proportional Reasoning and Piagetian Cognitive Development.

Shrestha, S.B. (1983) investigated the acquisition of problem-solving processes during adolescence using 38 variables on a sample of 400 adolescent pupils studying in grade V to IX. The following six factors were interpreted psychologically : Using constant difference, Using summation, Applying flexible or Comparative difference, Insight, Proportional reasoning and Grasping

the essence of the problem.

The Present Study

This study had mainly, two objectives in view. Firstly, it was to determine the mathematical structure of the variables used. Secondly, it was to determine whether all variables subjected to factor analysis appeared or not. Factor analysis is based upon correlation matrix.

Correlation Matrix

45 inter-correlations became available among the ten variables, considering the half correlation matrix, divided symmetrically by the diagonal as shown in Table XV. In all there are 39 Positive correlations out of which 35 are significant at .01 level, one is significant at .05 level and 3 are insignificant. There are also 6 negative correlations out of which 3 are significant at .05 level and the rest 3 are insignificant. These insignificant correlations between the variables are given below :

3rd and 2nd i.e. Constant difference and I.Q.
4th and 2nd i.e. Proportion and I.Q.
5th and 2nd i.e. Classification and I.Q.
6th and 2nd i.e. Conservation of volume and I.Q.
7th and 2nd i.e. Probability and I.Q.
10th and 2nd i.e. Stating Procedure and I.Q.

Therefore all the correlations are significant at .05 and .01 level except the correlations mentioned above.

Hence the fifth hypothesis i.e. There are significant correlations among all variables included in this study is largely speaking accepted.

Obtaining the Factors

As most of the correlations were found significant, it was decided to subject the correlation matrix to factor analysis, using hotelling method to study the mathematical structure of the adolescent thought. The major objective of this study was to make a comprehensive study of the mathematical structure underlying the various schemes of thought within Piagetian context. The factors appeared on factor analysis in this study are present in Table XVI.

Contd.

Table XVI

Varimax Rotated Factor Matrix for Variables 1 to 10

S.No.	Variables	Factor I	Factor II
1.	Age	0.84	0.32
2.	I.Q.	0.10*	-0.89
3.	Using Constant Difference	0.70	0.03*
4.	Using Proportion	0.74	0.08*
5.	Classification	0.73	0.14*
6.	Conservation of Volume	0.76	0.05*
7.	Probability	0.71	0.15*
8.	Testing Hypotheses	0.36	0.53
9.	Grasping the Essence of the Problem	0.77	0.31
10.	Stating Procedures	0.90	0.16*

* Supposed to be insignificant.

Interpretation of the Factors

A neat picture appears when it comes to the interpretation of various factors. Before describing this picture, it is necessary to make the following three remarks :

1. All the individual factor loadings have been reduced to two decimal places.
2. To simplify the interpretation of factors and to draw attention only to those factor loadings

which contribute significantly for determining the nature of the factor, factor loading below +.30 to -.30 have been ignored. Infact there is no definite criterion, how small factor loading should be ignored.

Benjamin Frucher (1967) has suggested that values of factor loadings less than .20 are, generally speaking, insignificant and hence can be ignored, whereas various other research workers have ignored values upto .300 (Vaidya, 1975). In the present study also the loadings of the different variables on the various factors having values numerically equal to or less than .300 have been ignored while interpreting the factors.

3. Usually speaking, any factor whose latent roots or eigen value is greater than one is supposed to be significant. In this study, out of 10 variables, only two factors appeared on the above mentioned criteria.

The first two factors, with their eigen values, percentage of variance and cumulative percentage of eigen values are shown in Table XVII.

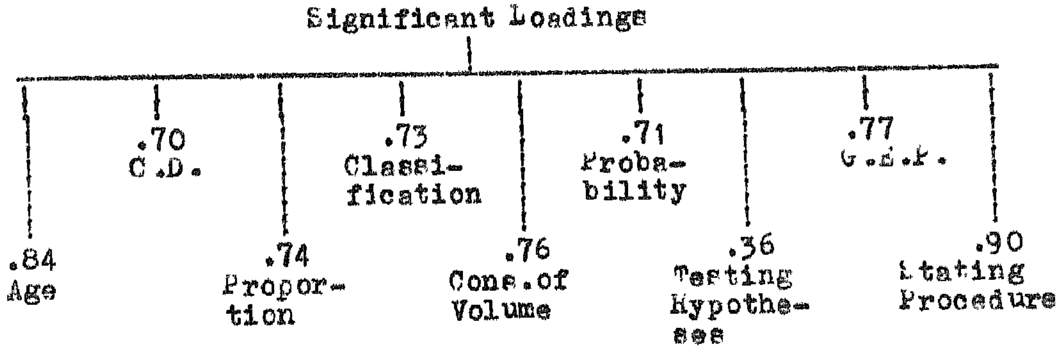
Contd.

Table XVII

Eigen Values, Percent of Variance and Cumulative Percentage for the Two Factors

S.No.of factor	Eigen values	Percent of variance	Cumulative % of Eigen value
1.	5.17	51.8	51.8
2.	1.14	11.5	63.2

Varimex Factor I



First Factor

It has high positive loadings on nine variables out of ten. Only one variable i.e. intelligence has insignificant loading. The highest loading .90 is on Stating Procedure. Other variables are also having significant loading on this factor. Taking an overall view, it can be interpreted as Formal Reasoning Factor comprising : Stating Procedure, Age, Grasping the Essence of the Problem (GEP), Conservation of Volume, Proportion, Classification, Constant Difference (C.D.) and Testing

Hypotheses. Interesting enough, it has a very high loading (.84) on age. This finding comes very close to the finding of Piaget when the various schemes of thought do depend upon age. This has happened at 11^{+} in our sample where the age range for the entire sample is from 11^{+} to 16^{+}.

So a research problem exists whether formal reasoning exists below 11^{+}. If it exists, does it depend more on age or I.Q.? Recently in a personal communication Professor P.E.Vernon has suggested this problem. How is it to be investigated is a matter of interdisciplinary approach? The problem as posed by him is as follows :

Does formal reasoning develop before 11^{+}?

Varimax Factor II

Significant Loadings

.32	-.89	.53	.31
Age	I.Q.	Testing Hypotheses	Grasping the essence of the Problem

Second Factor

The second factor has the highest loading (-.89) on intelligence. The Testing Hypotheses has the next highest loading (.53). Therefore this factor can be interpreted as Intelligence Factor.

Conclusion

To sum up, it can be safely said that within the context of our problems and tasks, the thought of adolescent girls of average achievement possesses two factors : age dependent formal reasoning factor and non-verbal aspect of intelligence as measured by Cattell's Culture Free-test Scale II, Form B.

Therefore, the sixth hypothesis i.e. A mathematical picture for the various schemes of thought and other tests, exists is accepted, which, on balance, turns out to be quite narrow. The reason for this is that number of variables included in this study were not many.

CHAPTER VII

SUMMARY, EDUCATIONAL IMPLICATIONS AND SUGGESTIONS

CHAPTER VII

SUMMARY, EDUCATIONAL IMPLICATIONS AND SUGGESTIONS

Introduction

Jean Piaget (1896-1980) is one of the most outstanding persons contributing to Psychology and education in the 20th century. He has become the most popular and most cited authority in the field of growth of logical thinking. He has studied the developmental aspect of human thinking and development of reasoning starting from birth till late adolescence. His work is based on extensive observation of individual children.

Piaget and his co-workers have written 30 volumes, a vast number of research papers, books and countless articles on the subject of infant and child thought. Piaget's theory has been more concerned with understanding, rather than controlling behaviour. According to him children develop intellectually in a sequence of stages by age from infancy to post-adolescence. There are four

major stages in Piaget's theory :

(i) Sensory-Motor stage (0-2 years)
(ii) Pre-operational stage (2-7 years)
(iii) Concrete-operational stage (7-11 years)
(iv) Formal-operational stage (11-15 years)

Past Work

Several researches have been done in the direction of 'Problem-Solving' and 'Intellectual Development'. The main researches related with the present study conducted by the various authors can be classified and are as follows:

(i) Studies on Problem-Solving Method

Heidbreder, E.(1928); Kyle, T.(1950); Buswell, G.T. (1956); Polya, G. (1957); Mealings (1961); Gunnels, F.G. (1967); Wonzy, C.D. and Cox, D.C. (1975); Klein, G.A. and Weitzenfeld, J. (1977); Dunlop, D.L. and Frank, F. (1977); Allowood, C.M. and Montogomery, H. (1979).

(ii) Studies on Relationship of Intelligence with Problem Solving and Intellectual Level of Development

Vaidya, N. (1964); Yudin, L.W. (1966); Bart, W.M. (1971); Misra, R.M. (1973); Cloutier, R. and Goldschmid, M.L. (1976); Gamoka, P.W. (1978).

(iii) Studies Related to the Relationship of the Intellectual Development with Problem Solving

Abramowitz, S. (1975); Morin, Joseph, G. (1978); Gartland, M.J. (1978); Vaidya, N. (1979); Jain, S.C.(1982);

Shrestha, S.D. (1983).

(iv) Studies Related with Stages of Development Using Written Piagetian Task

Karplus, R., Karplus, E., Forminsano, M., and Paulsen, A. (1975); Adi, Helen, Karplus, R., Lawson, Anton and Pulos, Stephen (1977); Shayer, M. and Wylam, H. (1978); Karplus, R., Adi, Helen, and Lawson, A.E. (1978); Walker, R.A., Hendrix, J.R. and Mirtens (1979).

(v) Studies on Stages of Development

Inhelder, B. and Piaget, J. (1958); Wheeler, D. (1958); Peel, E.A. (1960); Lovell, K. (1961); Beard, R.M. (1962); Jackson, S. (1965); Wells, J. (1972); Lawson, A.E. (1974); Waite, J.B. (1975); Clayton, V. and Overton, W.F. (1976); Mortorano, S.C. (1977); Sandhu, T.S. (1980); Padmini, M.S. (1982) and Jain, M. (1984).

This study differs from the above mentioned studies in following respects.

1. Sample (N = 150) is drawn from single girls' school.
2. In each sub sample (N = 25), girls of average achievement have only been included, their aggregated achievement ranging from 50 per cent to 59 per cent.
3. In each sub-sample, grade and age have also been controlled.
4. Several schemes of thought along with the errors committed during problem solving have been studied.

5. It has also been possible to determine the mathematical structure of the tests and tasks used in this study.

Problem Restated

The problem was stated as :

"Some Aspects of Logical Thinking Within Piagetian Context Among Certain Groups of Average Adolescent Girls".

Aims and Objectives of the Study

The present study aims at investigating following :

1. To study thinking (Problem-Solving) processes, evoked by individual problems, each containing a continuous chain of reasoning.

2. To study the same processes when appropriately grouped, regardless of the typology of problems.

3. To study errors as they occur in solving these problems.

4. To determine the relationships between scores on thinking and some outside variables : intelligence and age.

5. To analyse the structure of the appropriately grouped process of thought factorially and interpret them psychologically.

6. To point out the main educational implications based upon findings of the study.

Hypotheses to be Tested

The following hypotheses are proposed to be tested.

1. Poor problem - solvers are influenced more by the content rather than the form of the problem.
2. Complex problem-solving processes arise from simple problem-solving processes.
3. Scores on problem solving do not increase with age and grade.
4. Scores on various schemes of thought differ significantly from grade to grade.
5. There are significant correlations among all variables included in this study.
6. A mathematical picture for the various schemes of thought and other tests exists.

Method of Procedure

Sample and Subjects

A sample of 150 girls was selected randomly from Savitri Girls H.S. School, Ajmer. The age, I.Q. and grade were controlled, in order to get a homogeneous sample. The selected girls were of 11^+, 12^+, 13^+, 14^+, 15^+, 16^+ years age level in grade VI, VII, VIII, IX, X and XI respectively. Their I.Q's ranged from 89 to 110. From each grade equal number of girls (N = 25) was taken.

Tools Used

The following two tests were used in the present study for collecting the data :

1. Cattell's Culture - Free Test Scale 2, Form B - To measure I.Q.
2. Written Piagetian Type Tasks - Consisting of 12 problems and 42 processes.

The name of the problem and corresponding schemes of thought are presented in Table XVIII.

Table XVIII

Showing Names of the Problems and Schemes of Thought

S.No.	Name of the Problem	Schemes of Thought
1.	Height Problem	Using constant Difference
2.	Shadow Problem	Using Proportion
3.	VIII Class Problem	Classification
4.	Beakers Problem	Conservation of Volume
5.	Beads Problem	Probability
6.	Questions Inviting the wrong Answer	Grasping the Essence of the Problem
7.	Numerical Problem	Using Constant Difference
8.	Candle Problem	Using Proportion
9.	Ball's Problem	Conservation of Volume
10.	Card's Problem	Probability
11.	Meal Worm Problem	Testing Hypotheses
12.	Questions Inviting the wrong Answer	Grasping the Essence of the Problem

Statistical Analysis

The statistical techniques used in the analysis of the data are given below :

(i) Mean and Standard Deviation

(ii) The t-values were computed to find out significant difference between two comparative grades.

(iii) Correlation-coefficients were computed to determine relationship among all variables included in this study.

(iv) Factor analysis was used to study the mathematical structure of the various schemes of thought and other variable, like age and I.Q.

Delimitations

1. Girls of grade VI to XI were considered ranging within the age limits of 11^+ to 16^+ years.

2. They were selected from the single Hindi medium school.

3. Girls selected were of average I.Q. ranging from 89 to 110.

Main Findings

The main findings of this study are as follows :

1. Mean scores on each scheme of thought with occasional fluctuations show an increasing trend with age and grade.

2. There is a dip in means within the overall growth in some of the grades in the schemes of using

constant difference Classification and Conservation of Volume and Testing hypotheses due to hump effect.

3. The initial performance on various schemes of thought remains quite heterogeneous throughout the grade for the entire sample. However, it attains homogeneity in the closing grades.

4. The scheme of classification and Grasping the essence of the problem have attracted a large number of errors. Hump-effect on errors is noticed clearly. To illustrate Scheme of Proportion, Classification, Conservation of Volume, Probability, Testing Hypotheses and Grasping the Essence of the Problem suffer humps.

5. Girls of lower grades are influenced more by the content rather than the girls of higher grade.

6. About 50 per cent of the girls do not have experimental minds. Girls from grade VI to VIII and X are not in a position to test hypotheses.

7. More than 50 per cent of girls fail to grasp the essence of the problem.

8. The same observation applies to the schemes of thought, Grasping the essence of the problem, Conservation of volume, Classification and Probability.

9. Only 19 per cent of the girls are in a position to accept the absurd premises of the problematic situation or in other words they are in a position to reason formally.

10. Most of the problems selected for this study for investigating various schemes of thought are developmental in character as these show 't' differences at .05 and .01 level of significance from grade to grade.

11. There are significant correlations among all variables included in this study at .05 and .01 level, except the variable I.Q.

12. There is no significant correlation between I.Q. and other schemes of thought, these are, using constant difference, Proportion, Classification, Conservation of volume, Probability and Stating procedures. Significant correlations with I.Q. have not appeared possibly because of the restricted I.Q. for the girls selected for this study were of average achievement.

13. When tools and tests of this study were subjected to factor analysis, two factors, namely age dependent formal reasoning and intelligence factor appeared.

Educational Implications

This study was conducted within the Piagetian context. The Piagetian thought is a very highly theoretical system whose educational implications in their tested forms have yet to appear. Within the context of this study, it was found that some schemes of thought attracted a large number of errors. These errors stare in the face. Given the appropriate experimental materials, these errors can

be reduced to a great extent otherwise errors on fundamental concepts will continue to resist. Here ideas of Bruner, Ausubel and Gagne have lot of relevance. It is in this context alone that students will be able to assimilate knowledge as Piaget has talked of without offering any strategy.

Our study suggests indirectly that if pupils are trained in reflecting over their responses or judging the strengths and weaknesses of their responses better results may appear in the long run. Knowledge is power only when it is truly earned and gained. To detail further : Cognitive development, according to Piaget, occurs in substages, the stages are, however, sequential and, as a child develops he must necessarily move in a unitary direction with the process reflecting a consistent order and with more mature behaviour having its roots in the earlier stages. Full maturity is the final total integration of all preceding stages. Keeping this view in mind, the present study suggests following educational implications.

1. To make the children good problem-solving adults. Schools should provide opportunities to solve various types of problems throughout their school life, else should be made of experimental materials.

2. Curriculum should be planned in such a way so that the structure of content may be in accordance

with the level of intellectual development of the students. At formal stage (11-15 years) curriculum content should be based on Probability, Testing Hypotheses (Experimental work), Reasoning and Classification etc.

3. At formal stage students are more capable of thinking abstractly. Hence a teacher should teach abstract and formal concepts in senior grades. They should be encouraged to think formally in areas where they have great interest and background because their level of thinking is higher in this stage.

4. Students should be encouraged to perform such operations those involve : Hypothetical - Deductive thinking, Propositional thinking, Evaluating information, Originating problems, Reflexive thinking, etc.

5. As the maximum errors were confined to the schemes of thought grasping the essence of the problem and classification. To minimize the errors in this direction, a teacher should develop the classificatory skill among their students and allow them to think more on any problematic situation.

Suggestions for Further Research

For further fruitful research, few dimensions are mentioned as under :

1. This study may be replicated on a group of average adolescent boys.

2. A comparative study of logical thinking during problem-solving can be conducted on rural and urban children.

3. It is necessary to replicate this study at three levels of intelligence of adolescent pupils, including the variables sex and socio-economic status.

4. This phenomenon should be studied in relation to personality traits, creativity and different types of schools.

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APPENDICES

APPENDIX I

किशोर अवस्था के विद्यार्थियों की विचार-प्रक्रियाओं का
जाँच-पत्र भाग (१)

विद्यार्थी का नाम ....

लड़का या लड़की ....

पिता का नाम ....

उम्र ....

कक्षा एवं सेक्शन ....

रोल नम्बर ....

स्कूल का नाम ....

तारीख ....

SCORE SHEET

TASK NO.	1				2				3						4				5			6
Distribution of Scores	1	2	3	4	1	2	3	4	1	2	3	4	5	6	1	2	3	4	1	2	3	
TOTAL																						

कुछ समस्याओं पर आपके अपने विचार

यह आपकी परीक्षा नहीं है। इस जांच-पत्र द्वारा आपसे यह पता लगाना है कि जब आपको कोई समस्या हल करने के लिए दी जाती है तो उसे आप कहां तक हल कर पाते हैं। आगे आने वाले पृष्ठों पर कुछ समस्यायें दी गई हैं जो एक, दो या कई अन्य विधियों से हल की जा सकती हैं। किसी भी विधि से समस्या को हल करने की आपको पूर्ण स्वतन्त्रता है। क्योंकि आप सब अपने अपने ढंग से सोचते हैं और समस्याओं को हल करते हैं, इसलिए किसी भी विद्यार्थी को किसी दूसरे विद्यार्थी से पूछ कर या नकल करके किसी समस्या को हल नहीं करना है। आपके द्वारा दिये गये उत्तर गोपनीय रखे जावेंगे, आप उत्तर निःसंकोच भाव से दें। आपको प्रत्येक समस्या के लिए दिये गये निर्देशों के अनुसार समस्या को हल करना है। उदाहरणार्थ: - समस्याओं को हल करने में आपको चित्र बनाने होंगे या रिक्त स्थानों की पूर्ति करनी होगी या कोई विधि अथवा प्रयोग लिखनी होगी। अगर कोई समस्या आपको कठिन मालूम पड़े तो हिम्मत न हारिये। समस्या को दुबारा पढ़िये तथा हल कर डालिये। जांच-पत्र को प्रारंभ करने से पहले आप अपनी सभी शंकायें दूर कर लीजिये। जब तक आपको कहा न जाए लिखना प्रारंभ न करें और जब रुकने के लिए कह दिया जाए तो उसी समय लिखना बन्द कर दीजिए। आपकी लिखावट स्पष्ट व सुन्दर होनी चाहिए।

धन्यवाद।

समस्या नं० १

राम, श्याम से २ से०मी० लम्बा है। राम, मोहन से ३ से०मी० लम्बा है, राम, सोहन से ५ से०मी० ठिगना है। यदि राम की लम्बाई २०० से०मी० है, तो बताओ :-

प्रश्न १- मोहन की लम्बाई क्या है ?

उत्तर ____________________

प्रश्न २- श्याम की लम्बाई क्या है ?

उत्तर ____________________

प्रश्न ३- सोहन की लम्बाई क्या है ?

उत्तर ____________________

प्रश्न ४- सोहन श्याम से कितना ठिगना है ?

उत्तर ____________________

समस्या नं० २

एक मकान, लट्ठे तथा पेड़ की ऊँचाई क्रमशः ४० मीटर, ८ मीटर व १२ मीटर है। यदि पेड़ की छाया की लम्बाई १८ मीटर हो तो बताओ:-

प्रश्न १- मकान की छाया की लम्बाई क्या होगी ?

उत्तर ____________________

प्रश्न २- अपने उत्तर की व्याख्या कीजिये।

उत्तर ____________________

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प्रश्न ३- लट्ठे की छाया की लम्बाई क्या होगी ?

उत्तर ____________________

प्रश्न ४- अपने उत्तर की व्याख्या कीजिये।

उत्तर ____________________

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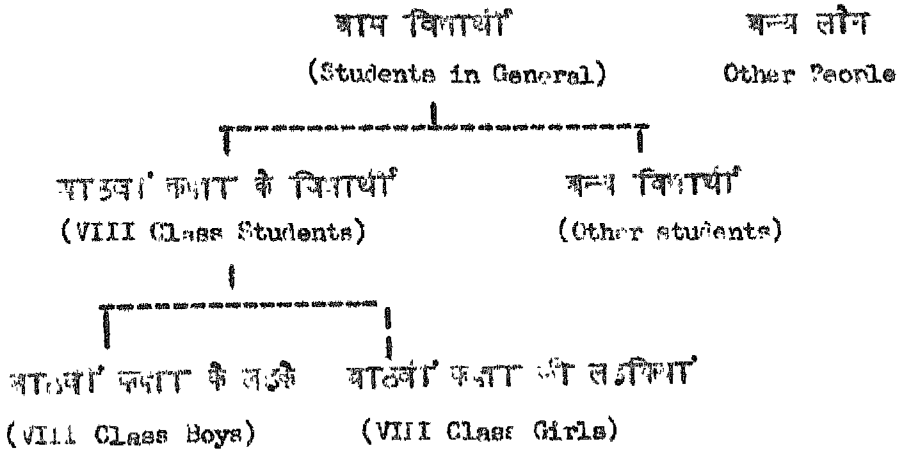
[illegible] नं० २

निम्न दिये हुए वर्गीकरण पदानुक्रम (Classification Hierachy) को अच्छी तरह देखिए और समझिए ।



अब आप नीचे दिए प्रश्नों के उत्तर लिखिए । याद रहे कि आपको उत्तर इसी वर्गीकरण पदानुक्रम के अनुसार लिखने हैं ।

प्रश्न १- यदि आठवीं कक्षा के लड़कों और आठवीं कक्षा की लड़कियों को एक साथ मिला दिया जाए तो इस समूह को आप क्या नाम देंगे ?

उत्तर ______________________________

प्रश्न २- यदि आठवीं कक्षा के लड़कों और आठवीं कक्षा के विद्यार्थियों को एक साथ मिला दें और उनके साथ आम विद्यार्थियों को भी मिला दिया जाए तो इस समूह को आप क्या नाम देंगे ?

उत्तर ______________________________

प्रश्न ३- यदि आठवीं कक्षा के विद्यार्थियों और आम विद्यार्थियों को एक साथ मिला दें और उनके साथ आठवीं कक्षा के लड़कों को मिला दिया जाए तो इस समूह को आप क्या नाम देंगे ?

उत्तर ______________________________

प्रश्न ४- यदि आठवीं कक्षा के लड़कों और बगैर किन्हीं विद्यार्थियों की कक्षा को एक साथ मिला दिया जाए तो इस समूह को आप क्या नाम देंगे ?

उत्तर ______________________________

प्रश्न ५- यदि आठवीं कक्षा के लड़कों और आठवीं कक्षा की लड़कियों को एक साथ मिला दें और इस समूह में से आठवीं कक्षा के लड़कों को निकाल दिया जाए तो इस बाकी बचे समूह को आप क्या नाम देंगे ?

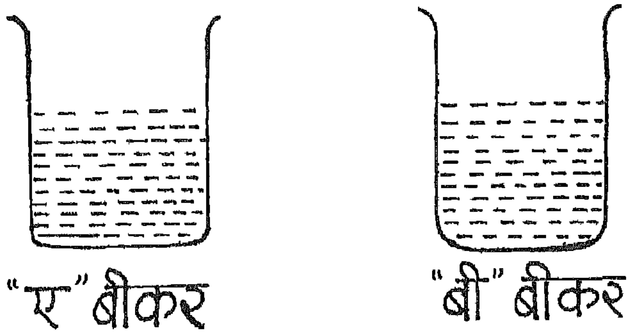
उत्तर ____

प्रश्न ६- यदि आठवीं कक्षा के लड़कों और आठवीं कक्षा की लड़कियों को एक साथ मिला दिया जाए तो इस समूह को आप क्या नाम देंगे ?

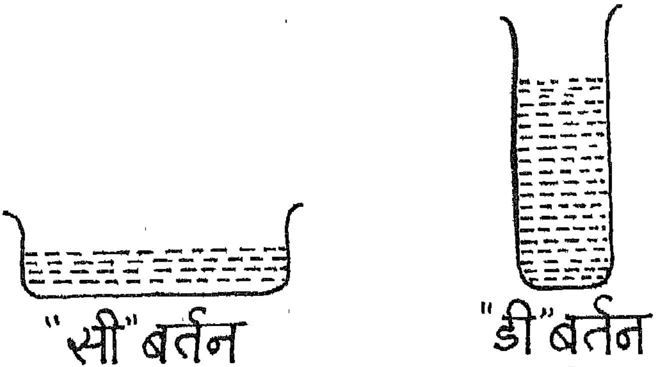
उत्तर ____

समस्या नं० ४

" ए " तथा " बी " दो बीकर हैं (चित्र नं०१.१) । जिनका कि आकार व आयतन बिल्कुल समान है । दोनों बीकरों (ए तथा बी) में १००-१०० ग्राम पानी भरा हुआ है । यदि " ए " बीकर का पानी चौड़े बर्तन " सी " में तथा " बी " बीकर का पानी संकरे मुंह वाले बर्तन " डी " में डालते हैं तो चित्र के अनुसार परिवर्तन होता है (चित्र नं० १.२) । चित्र को देख कर बताओ :-



चित्र नं. 1.1



चित्र नं. 1.2

प्रश्न १- " सी " तथा " डी " बर्तन में पानी की सतह में क्या अन्तर है ?

उत्तर ____

प्रश्न १– 'अ' तथा 'ब' बर्तनों में पानी की मात्रा में क्या अन्तर है ?

उत्तर ____

प्रश्न २– 'अ' तथा 'ब' बर्तनों में पानी के आयतन में क्या अन्तर है ?

उत्तर ____

प्रश्न ३– अपने उत्तर की व्याख्या कीजिये ।

उत्तर ____

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समस्या नं० ५

हमारे पास दो थैलियाँ 'अ' तथा 'ब' हैं । दोनों थैलियों में लाल तथा सफेद दोनों प्रकार की गोलियाँ हैं । थैली 'अ' में १२ लाल तथा २० सफेद गोलियाँ हैं । तथा थैली 'ब' में ३२ लाल तथा ६३ सफेद गोलियाँ हैं । बताओ –

प्रश्न १– दोनों थैलियों में कुल कितनी गोलियाँ हैं ?

उत्तर थैली 'अ' ____

थैली 'ब' ____

प्रश्न २– अगर हम बिना देखे हाथ डालकर गोली निकालना चाहें तो बताओ किस थैली में से लाल गोली आने की अधिक सम्भावना है ?

उत्तर ____

प्रश्न २– अपने उत्तर की व्याख्या कीजिए ।

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समस्या नं० ६

नीचे लिखे प्रश्नों को अच्छी तरह से पढ़िये, समझिये तथा उनके उत्तर लिखिये :–

प्रश्न १- कपड़े का १० मीटर लम्बा एक थान है, मशीनों से प्रत्येक मिनट में एक मीटर कपड़ा काटा जाता है, तो बताओ कितने मिनट में एक-एक मीटर के १० टुकड़े कट जायेंगे ?

उत्तर ....

प्रश्न २- एक रूमाल को धूप में सुखाने में दो मिनट लगते हैं, तो बताओ उसी प्रकार के २० रूमालों को उसी समय धूप में सुखाने में कितना समय लगेगा ?

उत्तर ....

प्रश्न ३- एक किलो लोहा तथा उतनी ही रुई एक तराजू के दोनों पलड़ों में रखे जाते हैं, बताओ किस ओर का पलड़ा ज्यादा झुकेगा और क्यों ?

उत्तर ....

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प्रश्न ४ - यदि एक अन्धा आदमी एक आँख से ५ मीटर तक देख सकता है, तो बताओ वह दोनों आँखों से कितनी दूरी तक देख सकेगा ?

उत्तर ....

प्रश्न ५- एक मनुष्य नाव से नदी को १५ मिनट में पार करता है, बताओ १० आदमी उसी नाव से उसी नदी को कितने समय में पार करेंगे ?

उत्तर ....

APPENDIX II

किशोर अवस्था के विद्यार्थियों की विचार-प्रक्रियाओं का

जाँच-पत्र भाग (२)

विद्यार्थी का नाम ……………………………………………………

लड़की या लड़का ……………………………………………………

पिता का नाम ……………………………………………………

उम्र ……………………………………………………

कक्षा एवं सेक्शन ……………………………………………………

रोल नम्बर ……………………………………………………

स्कूल का नाम ……………………………………………………

तारीख ……………………………………………………

SCORE SHEET

TALE NO.	7	8			9			10				11		12
DISTRIBUTION OF SCORES		1	2	3	1	2	3	1	2	3	4	1	2	
TOTAL														

समस्या नं० ७

नीचे दो पंक्तियों के समूह में कुछ संख्याएं लिखी हुई हैं। पहली पंक्ति की संख्याओं और दूसरी पंक्ति की संख्याओं को देखने पर आप इनमें कोई सम्बन्ध पायेंगे। इस सम्बन्ध को समझ कर दिये गये रिक्त कोष्ठक में उचित संख्या लिखिये।

०	५
५	१०
१०	१५
( )	२०
( )	२५
( )	( )
–५	–१०
–१०	– १५
–१५	–२०
–( )	–२५
– २५	–( )
–( )	–( )

समस्या नं० ८

एक जलती हुई मोमबत्ती को एक उल्टे रखे हुए जार के अन्दर रखते हैं तो वह मोमबत्ती तीन मिनट में बुझ जाती है। इस जार की क्षमता (आयतन) २ लीटर है। यदि मोमबत्ती को ४ लीटर वाले जार के अन्दर रखें तो बताओ:-

प्रश्न १- दोनों जारों में से किस जार की मोमबत्ती जल्दी बुझेगा ?

उत्तर ____________________

प्रश्न २- ४ लीटर वाले जार में मोमबत्ती को बुझने में कितना समय लगेगा ?

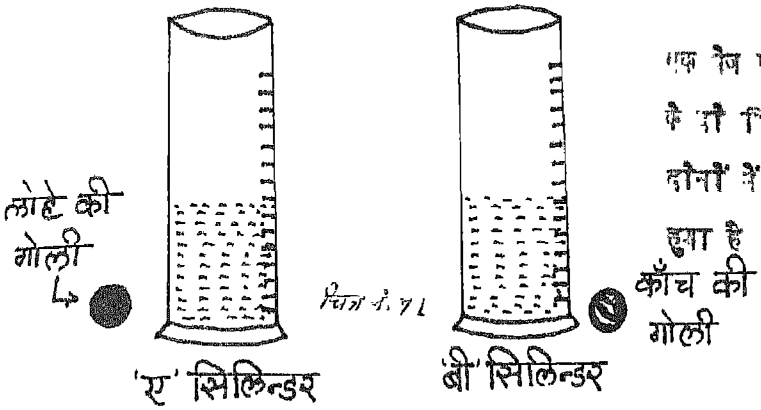
उत्तर ____________________

प्रश्न ३- अपने उत्तर का स्पष्टीकरण कीजिए।

उत्तर ____________________

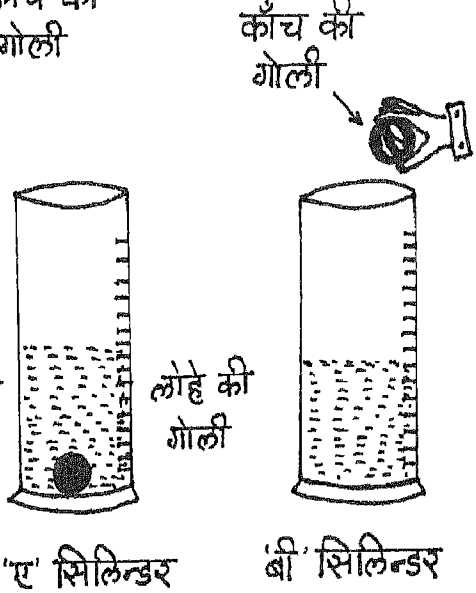
समस्या नं० ६

एक मेज पर समान आकार व आयतन के दो सिलिन्डर ए तथा बी रखे हुए हैं दोनों में समान सतह तक पानी भरा हुआ है । (चित्र नं० ७.१)



चित्र नं. 71

हमारे पास लोहे तथा कांच की दो गोलियां हैं । लोहे की गोली का वजन कांच की गोली की अपेक्षा अधिक है परन्तु आकार व आयतन दोनों का समान है । दोनों गोलियां पानी में डालने से डूब जाती हैं । जब हम लोहे की गोली को ए सिलिन्डर में डालते हैं तो पानी की सतह में परिवर्तन चित्र (नं० ७.२) में दिखाये अनुसार होता है । यदि हम कांच की गोली को बी सिलिन्डर में डालें तो बताओ :-



चित्र नं 72

प्रश्न १- बी सिलिन्डर में पानी की सतह अधिक हो जायेगी । कम हो जायेगी । वहीं रहेगी ।

उत्तर ....

प्रश्न २- बी सिलिन्डर में पानी की सतह किस नाप तक हो जायेगी ?

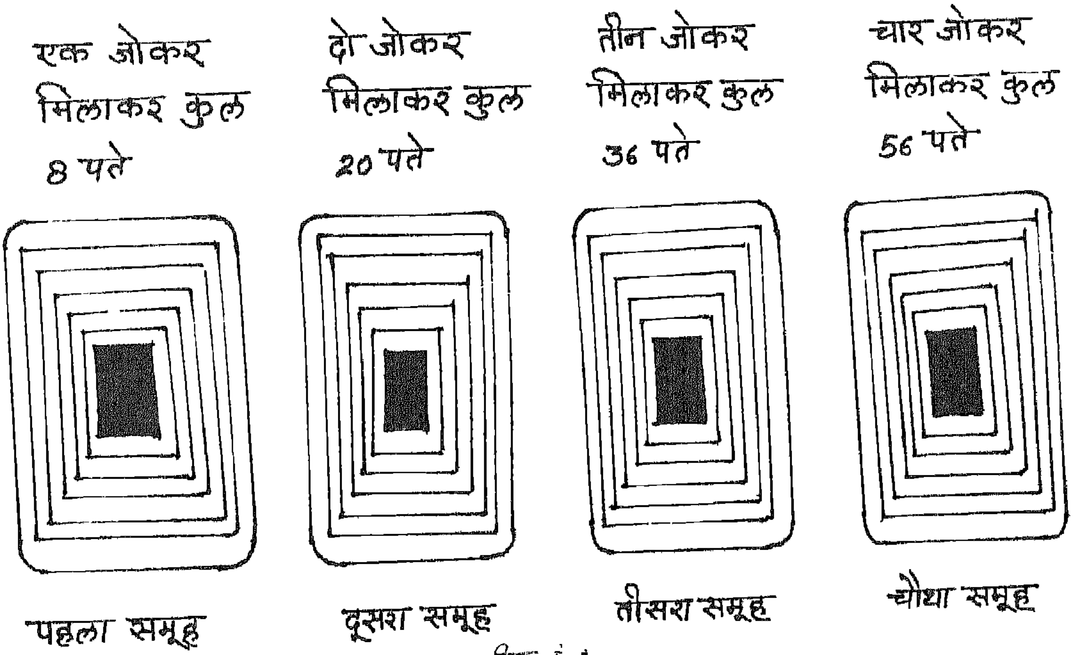
उत्तर ....

प्रश्न ३- अपने उत्तर की व्याख्या कीजिये ।

उत्तर ....

समस्या नं० १०

नीचे दिये गये चित्र में ताश के पत्तों के चार समूह दिखाये गये हैं। पहले समूह में ८ ताश के पत्ते हैं। इसी तरह दूसरे, तीसरे एवं चौथे समूह में क्रमशः २०, ३६, एवं ५६ ताश के पत्ते हैं। पहले समूह के ८ ताश के पत्तों में है, एक जोकर ताश का पत्ता भी है। इसी तरह दूसरे, तीसरे तथा चौथे समूह के पत्तों में भी क्रमशः दो जोकर ताश, तीन जोकर ताश तथा चार जोकर ताश हैं। प्रत्येक ताश का पत्ता पीछे से बिल्कुल समान है। बताइये :-


एक जोकर मिलाकर कुल 8 पते
दो जोकर मिलाकर कुल 20 पते
तीन जोकर मिलाकर कुल 36 पते
चार जोकर मिलाकर कुल 56 पते
पहला समूह
दूसरा समूह
तीसरा समूह
चौथा समूह

चित्र नं 4

प्रश्न १- किस समूह में से जोकर जल्दी मिलने की सम्भावना है ?

उत्तर ______________________________

प्रश्न २- अपने उत्तर को स्पष्ट कीजिये।

उत्तर ______________________________

____

प्रश्न ३- यदि पहले और चौथे समूह तथा दूसरे और तीसरे समूह के पत्तों को मिला दिया जाये तो किस समूह में से जोकर जल्दी मिलने की सम्भावना होगी ?

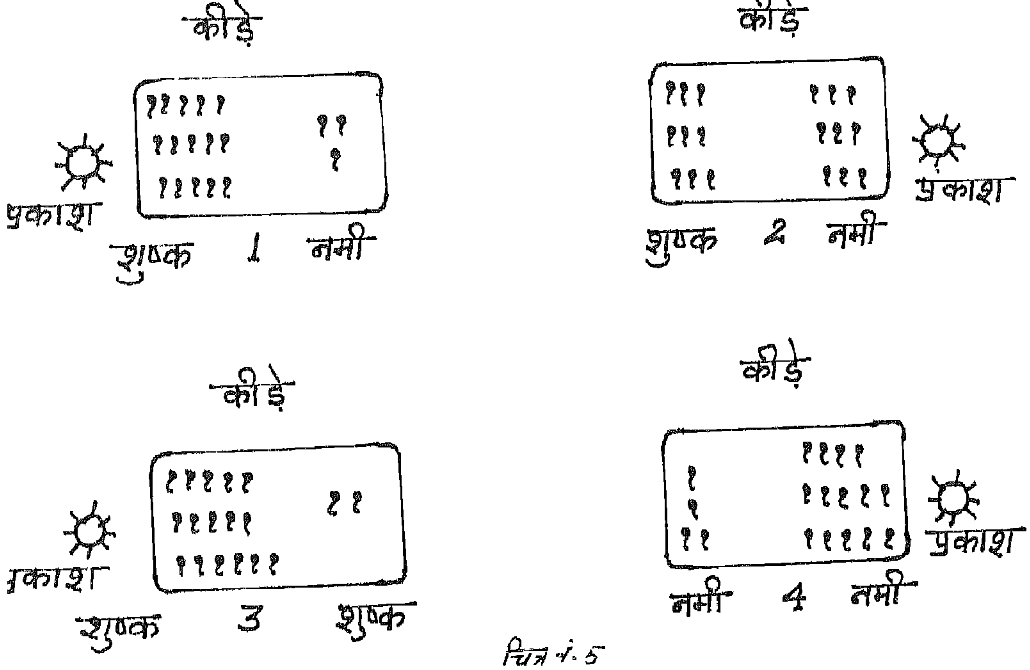
उत्तर ______________________________

प्रश्न ३- अपने उत्तर को स्पष्ट कीजिये ?

उत्तर ——————————————————————————————————

समस्या नं० ११

एक छात्र ने यह मालूम करना चाहा कि कीड़े किस तरह प्रकाश एवं नमी में रहते हैं। इसके लिए उसने चार कांच के बाक्स लिये, प्रकाश के लिये बल्ब का प्रयोग किया तथा नमी के लिये बाक्स में गीला कागज रखा। प्रत्येक बाक्स के मध्य में १८ कीड़े रखे। एक दिन के बाद सब कीड़े बाक्स में विभिन्न भागों में वितरित हो गये जैसा कि चित्र में दिखाया गया है। चित्र देखकर बताओ :-



चित्र नं. 5

प्रश्न १- पहले तथा तीसरे बाक्स से आप क्या निष्कर्ष निकाल रहे हैं ?

उत्तर

प्रश्न २- दूसरे तथा चौथे बाक्स से आप क्या निष्कर्ष निकाल रहे हैं ?

उत्तर

तालिका नं० १२

नीचे लिखे गये प्रश्नों को अच्छी तरह से पढ़िये, समझिये तथा उनके उत्तर लिखिये :-

प्रश्न १- यदि एक गधे के दो टांग हैं तो बताओ ६ गधों के कितनी टांग होंगी ?

उत्तर ____________________

प्रश्न २- एक आयत के चार कोने हैं, यदि एक कोने को काट दिया जाये तो कितने कोने शेष रहेंगे ?

उत्तर ____________________

प्रश्न ३- एक गाय के गले में एक मीटर लम्बी रस्सी बंधी हुई है तथा गाय पेड़ के पास खड़ी हुई है। बताओ गाय कितनी दूर तक जा सकती है ?

उत्तर ____________________

प्रश्न ४- एक पेड़ पर १७ पक्षी बैठे हैं, शिकारी ने एक पक्षी को बन्दूक से मार दिया। बताओ बाकी कितने पक्षी पेड़ पर बचे होंगे ?

उत्तर ____________________

प्रश्न ५- पानी में कुछ बतखें तैर रही हैं, जिनमें से दो बतखें आगे हैं, दो बतखें बीच में हैं तथा दो बतखें पीछे हैं। बताओ कम से कम कुल कितनी बतखें पानी में तैर रही हैं ?

उत्तर ____________________

APPENDIX III

Written Piagetian Type Tasks :

The test is divided in two parts : Section (1) and Section (2) each section consists of 6 problems.

Task 1

Height Problem

Ram is taller than Shyam by 2 cms. Ram is taller than Mohan by 6 cms. Ram is shorter than Sohan by 6 cms. If Ram's height is 200 cms., then answer the following questions?

1. What is height of Sohan?

____

2. What is the height of Shyam?

____

3. What is the height of Mohan?

____

4. How much is Mohan shorter than Shyam?

____

Task 2

Shadow Problem

The heights of a building, a pole and a tree are 50 metre, 4 metre and 12 metre respectively. If the length of the tree's shadow is 18 metres, then answer the following questions :

1. What will be the length of the shadow of the building?

____

2. Give explanation of your answer.

3. What will be the length of the pole's shadow?

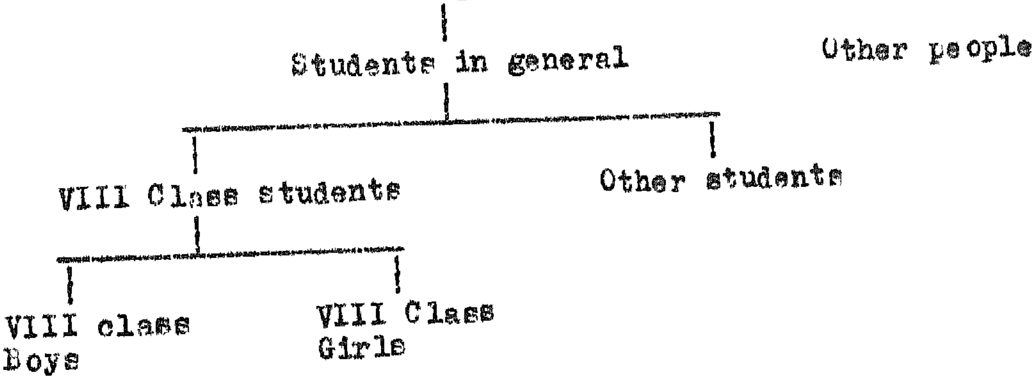
4. Explain your answer.

Task 3

VIII Class Problem

Look through the classification heierachy given below and with the understanding of it answer the questions given below :

Fig.



1. If VIII class boys and VIII class Girls are grouped together, what name will you give to the group formed?

2. If VIII class boys are grouped with VIII class students and then both in combination are grouped with students in general, what name will you give to the group formed?

3. If VIII class students are grouped with students in general and then in combination are grouped with VIII class boys, what name will you give to the group formed?

____

4. If VIII class boys are grouped with a class without students what name will you give to the group formed?

____

5. If VIII class boys are grouped with VIII class girls and then VIII class boys are taken out from the group, what name will you give to the group left behind?

____

6. If VIII class boys are grouped with VIII class boys, what name will you give to the group formed?

____

Task 4

Beakers Problem

There are four beakers A, B, C and D. Beaker A and B are of the same size and volume and contains 100 c.c. of water each. Beaker C is broad and beaker D is narrow and long as shown in the diagram given below. Water from beaker A is poured into beaker C and water from beaker B to beaker D. Now answer the following questions :

1. What is the difference in the level of water in the beakers C and D?

____

2. What is the difference in the quantity of water in beakers C and D?

____

3. What is the difference in the volume of water in the beakers C and D?

____

4. Explain your answer?

____

Task 5

Beads Problem

We have two bags A and B. Both the bags contain red and white marbles. Bag A contains 12 red and 20 white and Bag B contains 33 red and 63 white marbles. Now, answer the following questions :

1. What is the total number of marbles in the bags A and B?

Bag A ________________
Bag B ________________

2. In case we draw a handful of marbles from the bag without looking into it, from which bag is there a chance of drawing more red marbles?

____

3. Give reason for your answer?

____

Task 6

Questions inviting the wrong answers

1. A bale of cloth is ten meter long. It takes one minute to cut one meter of cloth. How much time will it take to cut off ten meters of cloth?

2. A handkerchief takes two minutes to dry up in the sunlight. How much time it will take for twenty to dry up when placed in the Sun at the same time?

3. If we keep one kilogram of Iron on one pan of a balance, and one kg. of cotton on the other, which of the two pans will be lowered and why?

4. A blind man with one eye can see upto a distance of 5 metres. How far can he see with two eyes?

5. A man crosses a stream by a boat in fifteen minutes. How much time take for ten to cross the same stream in the same boat?

Task 7

Numerical Problem

We have written some figures against each other in two columns. As you go down the columns, there appear some relationship. Try to understand it. Then fill in the blanks indicated by the question mark :

1. 0 5

2. 5 10

3. 10 15

4. ? 20

5. ? 25

6. ? .... ?

7. -5 .... -10

8. -10 .... -15

9. -15 .... -20

10. ? .... -25

11. -25 .... -?

12. -? .... -?

Task 6

Candle Problem

When a jar is inverted over a lighted candle, it goes off within three minutes. This jar has a volume of 2 litres. In case a jar of 4 litres is inverted over the burning candle, answer the following questions :

1. In which jar does the candle burn for less time?

2. For how long does the candle burn in the four litre jar?

3. Give reasons for your answers?

Task 9

Ball's Problem

Two cylinders A and B of the same volume and size are kept on a table and water is filled in both upto the level 6 c.c. as shown in the figure given below. We have two sphears (balls) one is made of iron and the other of glass. They are both of the same volume and size but of different weights. When both are put in the water, they sink to the bottom of the cylinders.

When the iron sphere is put in cylinder A, the level of the water raises from 6 c.c. to 10 c.c. Now, if we immerse the glass sphere in the water of cylinder B, then answer the following questions:

1. Will the water level in the cylinder B rise / fall / remain the same?

   ____

2. In case it changes, what will be the new level?

   ____

3. Explain your answer?

   ____

Task 10

Card's Problem

There are four sets of cards. In the first set, there are 8 cards, which includes one joker. In the second set, there are 20 cards, which includes two jokers. In the third set, there are 36 cards, which includes 3(three) Jokers and in the fourth set, there are 56 cards, which includes four jokers.

There is the same design on the backs of all these cards. Looking at the diagrams answer the following questions :

From which set is there more chance of getting the joker card?

____

Give reason for your answer?

____

If the cards of the first and the fourth, and the cards of the second and third sets are mixed then, from which set is there more chance of getting the joker easily?

____

Give reasons for your answers?

____

Task 11

Meal Worm Problem

A student wanted to know how worms move about in light and moisture (wetness). To solve this problem, he placed 18 worms in the centre of each of the four glass boxes under different conditions of light and moisture. For moisture, water was sprinkled on the bits of paper in the whole box or in half the portion of the box as required. Light was provided by the electric bulb to the required part of the box. After a day only, the worms move and change their places in the box. After a day only, the worms move and change their places in the box. Look at the diagrams carefully and answer :

1. What do you conclude from the diagrams (1) and (3)?

____

2. What do you conclude from the diagrams (2) and (4)?

____

Task 12

Questions inviting the wrong answers

1. Suppose a donkey has two horns. How many horns in all nine donkeys will have?

____

2. How many corners of the handkerchief are left if you cut off one of its corner with the help of a pair of scissors?

____

3. A cow is standing beside a tree. A cord of one metre is tied arround her neck. Tell how far can she go for eating the grass?

____

4. 17 birds were sitting on a tree the hunter shot down one of them. How many birds were left on that tree?

____

5. Some ducks are floating in the water. Out of them two are ahead, two in the middle and two at the back. Show atleast how many ducks are floating in the water?

____

APPENDIX IV

Original Data Regarding the Different Variable to be read as follows

Column No.	Description of the variable	Short notation used if any	Variable No.
1, 2, 3	Serial number of Girls	S.No.	-
4, 5, 6	Age of Girls in months	-	1
7, 8, 9	Intelligence quotient	I.Q.	2
10, 11	Using Constant difference	-	3
12	Using Proportion	-	4
13	Classification	-	5
14	Conservation of Volume	-	6
15	Probability	-	7
16	Testing hypothesis	-	8
17, 18	Grasping the essence of the problem	-	9
19, 20	Stating Procedures	-	10

Variable No.				1			2			3		4	5	6	7	8	9		10	
Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	0	0	1	1	1	3	0	8	9	0	6	4	0	1	3	0	0	3	0	3
	0	0	2	1	3	3	1	0	0	0	9	2	0	1	4	6	0	3	0	4
	0	0	3	1	3	3	0	6	9	0	6	0	0	1	4	0	0	3	0	4
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	0	0	5	1	3	0	1	0	0	0	0	4	2	3	1	0	0	2	0	2
	0	0	6	1	3	6	0	9	6	0	6	2	0	0	2	6	0	2	0	0
	0	0	7	1	4	1	0	6	9	0	3	0	0	2	3	6	0	3	0	2
	0	0	8	1	3	8	0	9	9	0	0	4	1	0	2	0	0	2	0	0
	0	0	9	1	4	1	0	8	9	0	6	4	3	1	2	0	0	2	0	2
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	0	1	7	1	3	3	1	0	7	0	0	4	3	3	2	0	0	4	0	2
	0	1	8	1	3	2	1	0	3	0	6	4	0	2	3	0	0	4	0	0
	0	1	9	1	3	2	1	0	7	1	2	4	1	7	6	0	0	4	1	0
	0	2	0	1	4	1	0	9	1	0	6	2	3	0	2	0	0	3	0	0
	0	2	1	1	3	6	0	8	9	0	0	2	2	0	2	6	0	2	0	0
	0	2	2	1	4	1	0	9	9	0	6	4	3	4	2	0	0	2	0	2
	0	2	3	1	3	2	0	9	3	0	3	2	0	3	4	0	0	5	0	2
	0	2	4	1	4	1	0	9	1	0	6	4	2	1	4	0	0	4	0	0
	0	2	5	1	3	3	1	0	0	0	6	2	0	2	4	0	0	4	0	2

Variable No.				1			2			3		4	5	6	7	8	9		10	
Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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	0	5	0	1	4	5	0	9	5	0	3	2	3	3	3	6	0	3	0	2

Variable No.				1			2			3		4	5	6	7	8	9		10	
Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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	0	5	7	1	5	7	0	9	2	0	[illegible]	4	0	1	4	0	0	8	0	4
	0	5	8	1	5	8	0	9	6	0	0	4	2	0	3	0	0	8	0	0
	0	5	9	1	5	8	0	9	2	0	0	4	2	0	4	6	0	7	0	6
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Variable No.				1			2			3		4	5	6	7	8	9		10	
Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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Variable No.				1			2			3		4	5	6	7	8	9		10	
Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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Variable No.				1			2			3		4	5	6	7	8	9		10	
Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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